THE CERVICAL SYNDROME

Publication Number 334
AMERICAN LECTURE SERIES®

A Monograph in
The BANNERSTONE DIVISION *of*
AMERICAN LECTURES IN ORTHOPAEDIC SURGERY

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(Second Edition)

THE CERVICAL SYNDROME

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CHARLES C THOMAS PUBLISHER

Springfield Illinois U.S.A.

CHARLES C THOMAS PUBLISHER
BANNERSTONE HOUSE
301 327 East Lawrence Avenue, Springfield, Illinois, U.S.A.

Published simultaneously in the British Commonwealth of Nations by
BLACKWELL SCIENTIFIC PUBLICATIONS, LTD OXFORD, ENGLAND

Published simultaneously in Canada by
THE RYERSON PRESS, TORONTO

First Edition, January 1956
Second Edition, July 1958

Library of Congress Catalog Card Number 58-10274

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FOREWORD

THERE are few problems of greater complexity than what the author calls the cervical syndrome It is truly kaleidoscopic in its ramified clinical manifestations Many men might have yielded to the temptation of a purely descriptive approach and to handcuff the subject by extensive subdivisions on purely observational grounds. It is *in this particular aspect* that Dr Jackson s monograph is notably different. In her quest to give the mass of symptoms which meet the eye interpretative meaning she not only draws heavily upon information furnished by the basic sciences, but the whole structure of the work is built upon basic and recognized factors in the field of anatomy and kinetics In her attempt to establish the causal connections between basic facts and clinical manifestations, she succeeds uncommonly well

One of these facts is the relation of the much ignored unco-vertebral articulation to foraminal compression Another is the anatomical relations which the sympathetic nervous system of the cervical spine bears to certain projected localizations of pain

In perusing the book carefully as the writer has done, one cannot help but credit Dr Jackson of having developed on the foundation of basic facts a clear cut pattern of logical coherence between *the manifestation and background* which should do much for the understanding of a most difficult clinical entity

This present monograph is preceded by a number of publications and instructional courses pertaining to this subject which Dr Jackson has given for a number of years. Her very large clinical experience well documented in this

book enjoins the reader to give serious consideration to her statements.

It has been my privilege to know Dr Jackson for many years and to follow the keen interest she has taken in this subject and the earnest and intensive studies she has devoted to it. They have made her one of the foremost authorities in this specific field

A. STEINDLER, M D

Iowa City, Iowa

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THE CERVICAL SYNDROME

Chapter 1

INTRODUCTION

THE term *Cervical Syndrome* is used to signify a group of symptoms and clinical findings which occurs as a result of irritation or compression of the cervical nerve roots in or about the intervertebral foramina before they divide into anterior and posterior primary rami. The word *syndrome* has been used with many other descriptive words to indicate special conditions at specific locations when in reality the true pathology involves the nerve roots themselves. The vast number of these syndromes which are concerned with head, neck, shoulder and arm pain and disabilities are somewhat confusing if one attempts to rationalize concerning their etiological significance

An understanding of the anatomy of the cervical spine and of the mechanism involved in cervical nerve root irritation will clarify some of the confusion and will assure treatment directed toward the true causative factors

The development of the cervical portion of the spine and the many congenital anomalies which occur are well described by Hadley in his book *The Spine*[1] The excellent anatomico-radiographic reproductions in this book should be studied by all who are interested in the cervical spine

Chapter 2

ANATOMY

THE cervical spine has certain definite characteristics which make it more subject to injury than any other portion of the vertebral column. It is vulnerably placed between the dorsal spine, which is relatively immobile, and the skull which is a weight that must be balanced on the cervical spine and which is held in place by the supporting capsular ligamentous and muscular structures. It is necessary because of the special sense organs of sight and hearing that the neck have a great range of motion in all directions. The position and the mobility of the neck are therefore two important factors in its vulnerability to injury.

MOBILITY

The mobility of the cervical spine is dependent upon the composite motion between all the vertebrae and not upon the small amount of motion which occurs between any two of them. The slight flexibility of the intervertebral discs, the shape and inclination of the primary articular processes and their incomplete apposition as well as the slight laxity of the ligamentous and capsular structures determine the range of normal motion.

The special architectural design of the atlas and axis, or the first two cervical vertebrae, permits nodding, rotation and lateral bending movements of the head. The head and atlas move primarily as one unit on the axis in rotation and lateral bending movements. Due to the shape of the atlanto-occipital articulations and the laxness of their joint capsules

nodding movements are fairly free. The range of backward movement is greater than the range of forward movement

The motion between the atlanto-axial joints takes place around transverse, anteroposterior and vertical axes. Nodding or bending the head forward and backward, occurs about the transverse axis. Bending the head sideways occurs about an anteroposterior axis which is inclined upwards and forwards so that when the head is bent to one side the face is slightly turned towards the opposite side Rotation of the head occurs around a vertical axis (Figure 1)

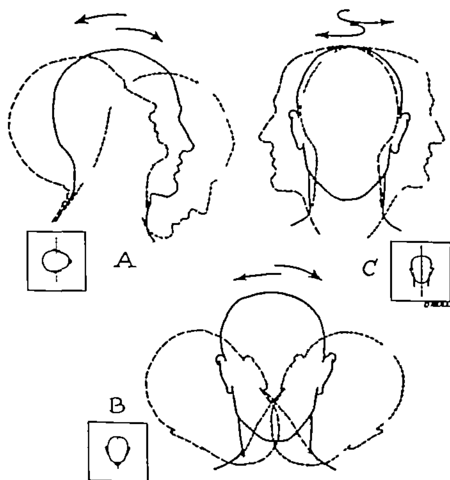


FIGURE 1 Axes of motion (A) Nodding occurs about a transverse axis. (B) Lateral bending occurs about an anteroposterior axis. (C) Rotation occurs about a vertical axis.









←FIGURE 2 Radiographs of the first two cervical vertebrae which show the relationship of the lateral masses of the atlas to the odontoid process of the axis. The heads are straight in (A) and (C) The head is rotated to the left in (B) and in (D) the head is rotated to the right There is no change in the relationship of the atlanto-axial joints, and the lateral masses maintain a constant relationship with the odontoid process in radiographs.

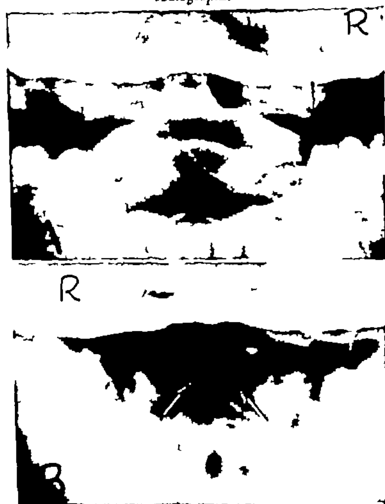


FIGURE 3 Fracture of the base of the odontoid process with lateral tilting toward the left lateral mass of the atlas is shown in the radiograph in (A) This patient, age nine, was hit in the back of the neck with a stick when he was in a stooped position. It was necessary eventually to fuse the first and second vertebrae.

A rudimentary disc between the odontoid process and the body of the axis is shown in (B) This patient, age eight and a brother of the patient shown in (A) fell out of bed. Note the line of decreased density at the base *of the odontoid the shape of the* odontoid and the relation ship of the lateral masses to the odontoid and to each other

As rotation of the head and atlas takes place upon the axis the inferior facets of the atlas slip forward and backward over the superior facets of the axis. As one watches this rotatory movement it can be seen that the lateral masses of the atlas change their relationship to the odontoid process Turning the head to the left, let us say, causes the anteromedial surface of the right lateral mass, or articular process of the atlas to approach the odontoid process, while on the left side the posteromedial surface of the left lateral mass approaches the odontoid process In radiographic films the relationship of the lateral masses of the atlas to the odontoid process appears the same as if the head and atlas had not been rotated (Figure 2) Any appreciable disproportion between the lateral masses of the atlas and the odontoid process of the axis as seen in radiographs is due *to a lateral subluxation of the altas on the axis, to a fracture-*displacement of the odontoid process or to a congenital anomaly (Figure 3(A)&(B))

The articular surfaces of the lateral masses of the atlas and the superior articular processes of the axis are not at full apposition when the head is facing straight forward, so that slight tilting of the head to one side is the position of greatest ease and stability *

Motion in the other cervical joints consists of forward flexion, hyperextension, lateral bending and rotation. Here, also the primary or posterior articulations are not in true apposition when the head faces straight ahead so that the position of ease and stability occurs when the head and neck are tilted slightly to one side.

Movement in the cervical area is very free when that portion of the spine is considered as a whole. The plane of the articular surfaces facilitates flexion and hyperextension but prevents lateral bending to occur without some degree of rotation, or rotation to occur without some degree of lateral bending (Figure 4A&B) Forward bending of the neck causes each of the spinous processes to separate

from each other, whereas hyperextension causes them to approximate each other. Fielding[9] has shown by cineradiography that there appears to be a gliding movement between the vertebral bodies, which is due, of course, to the elasticity of the nucleus pulposus of the intervertebral disc which tends to equalize the pressure in each disc as the bending movements take place.[3] The arrangement of the



FIGURE 4A. Anteroposterior x-ray film of cervical spine made with the neck in rotation. Rotation is accompanied by lateral bending.

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abnormal range of motion or slipping between the articular surfaces.

JOINTS

The lateral atlanto-axial joints are inclined slightly laterally and downward and are known as plane joints (Figure 5) The inferior articular surface of each lateral mass of the atlas is somewhat concave to conform to the convex articular surface of the superior facets of the axis. The superior facets of the axis are placed on the body and pedicles and it is through them that the weight of the head is transmitted from the lateral masses to the vertebral bodies below

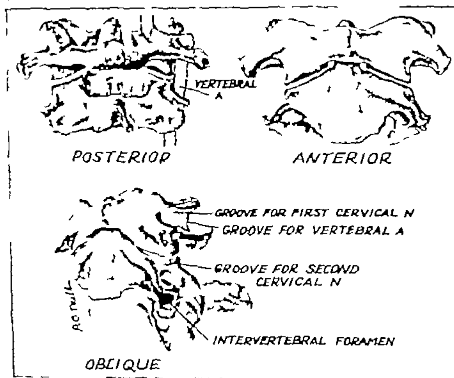


FIGURE 5 Atlanto-axial articulations.

The medial atlanto-axial joint or the articulation of the odontoid process with the atlas, is a pivot joint with two synovial cavities, one between the anterior arch of the atlas and the odontoid process and the other between the pos-

fibers within the discs definitely restricts movement between adjacent vertebral bodies, but a minimum amount of motion does occur in all directions.

The ligamentous and capsular structures are somewhat lax to permit a normal range of motion. Undue laxness gives rise to subluxations of the articulations, or allows an



FIGURE 4B. Anteroposterior x ray film of cervical spine made with the neck in lateral bending. Lateral bending is accompanied by rotation.

toid process which occur as a result of minimum trauma, as well as for the so-called epiphyseal separations of the odontoid processes which occur in children (Figure 3(B)) Other congenital anomalies of these two vertebrae are well described and illustrated in Hadley's book *The Spine* [19]

The joints of the cervical spine below the atlanto-axial articulations are of special design In the dorsal and lumbar areas of the spine there are three articulations between each two adjacent vertebrae the two posterior or apophyseal joints and the secondary cartilaginous joint or the intervertebral disc. In the cervical area, however, there are two interbody articulations Or a total of five articulations between each two vertebrae (Figure 9)

The posterior joints are formed by the articular processes of the vertebral arches. The articular surfaces of these joints are almost flat and the planes of the joints face obliquely upward at an angle of approximately forty-five degrees, except between the second and third vertebrae where the angle of inclination varies (Figure 7)

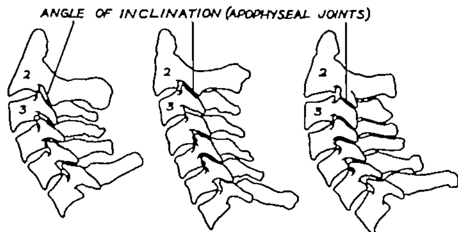


FIGURE 7 Angle of inclination of the posterior or apophyseal joints. Note variations between C2 and 3 (Tracings of x-ray films.)

The intervertebral discs are unusual in the cervical area. The vertical diameter or the height of the discs is two or three times greater at the anterior margins than at the pos-

terior surface of the odontoid and the transverse ligament of the axis (Figure 6)

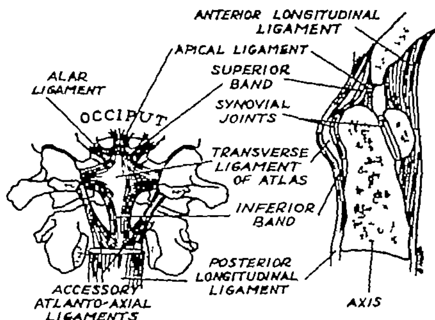


Figure 6. Atlanto-axial ligaments. Note the thickness of the transverse ligament.

Excessive movement in the atlanto-axial joints in any direction is checked by the special ligaments of these vertebrae (Figure 6) These check ligaments, including the capsular ligaments, are very strong and are responsible for maintaining the head and atlas in their proper relationship to the axis. The odontoid process of the axis provides a pivot primarily and does not by itself prevent luxation of the head and atlas on the axis. Anterior dislocation of the atlas on the axis can occur only when the restraining ligamentous and capsular structures are torn Posterior dislocation can occur only if these structures are torn and there is a facture of the anterior arch of the atlas, or if there is a fracture of the odontoid process

A rudimentary disc may be found between the odontoid process and the body of the axis in some instances This accounts for some of the fracture-dislocations of the odon-

bodies of the vertebrae and the corresponding beveled areas on the inferior surfaces (Figure 9)

Von Luschka[30] described these articulations in 1858 as true joints with capsules, synovial linings and articular cartilage He gave them the name of "hemiarthroses inter-

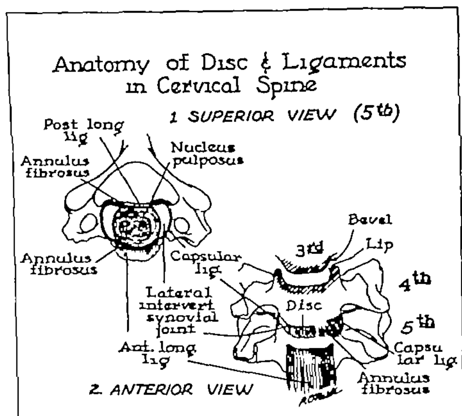


FIGURE 9 Intervertebral disc and lateral intervertebral joints. Disc does not extend to lateral side of vertebral bodies because of the lateral intervertebral joints.

vertebrales laterales." Trolard[44] described them in 1892 and called them "articulations uncovertebrales" Cunningham's *Text Book of Anatomy*[8] points out that the articular processes of the altas and the superior articular processes of the axis are placed on the body and pedicles rather than at the junction of the pedicles and laminae as they are in the other areas of the spine The atlanto-occipital and the

terior margins, which permits a normal forward curve in the cervical area of the spine and permits the discs to conform to the contour of the vertebral bodies. This characteristic occurs in the lumbar area, but for the most part to a lesser degree (Figure 8)

The nucleus pulposus of a cervical disc is placed slightly anterior to the middle of the disc The annulus fibrosus of the disc is thicker posteriorly than it is anteriorly and it bulges or protrudes anteriorly beyond the adjacent vertebral bodies (Figure 8)

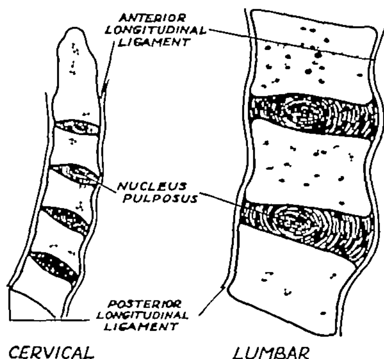


FIGURE 8 Median section of cervical and lumbar vertebrae to show position of nucleus pulposus and vertical diameter of discs.

The cervical discs do not extend to the lateral and posterolateral margins of the vertebral bodies, in as much as there are interbody articulations located at these areas. These interbody articulations are formed by the upward posterolateral projections on the superior surfaces of the

ligament extends across their curved posterolateral margins The capsular ligaments arise from the posterolateral surfaces of the vertebral bodies and from the deep layer of the posterior longitudinal ligament which is a strong two-layered structure in the cervical area. The superficial layer of the posterior longitudinal ligament covers the capsular ligaments posteriorly and laterally The capsular ligament passes obliquely across the margins of the interbody joints to gain attachment close to the margin of the upward lateral projection of the adjacent distal vertebra (Figure 11) This provides for a more extensive proximal attachment of the ligament than distal attachment The capsular ligaments are short and taut, and therefore, lack the laxity which is characteristic of the capsules of the posterior joints

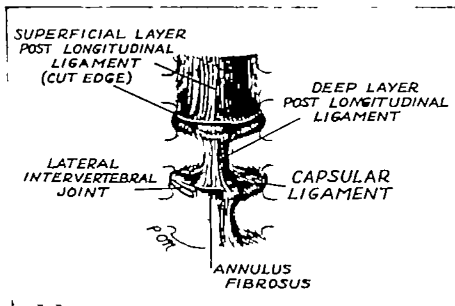


FIGURE 11 The two-layered posterior longitudinal ligament and the capsular ligaments of the lateral intervertebral joints.

The presence of a space between the articular surfaces of the posterolateral areas of the vertebral bodies is shown in Figure 12 A radio-opaque material was injected into some of the interbody articulations of a specimen and then

atlanto-axial joints correspond to the small joints between the bodies of the other cervical vertebrae rather than to the posterior articular processes. This arrangement leaves the first and second nerve roots lying posterior to the lateral joints without intervertebral foramina (Figure 10A) The other nerve roots lie anterior to the posterior articulations and posterior to the joints between the lateral portion of the vertebral bodies or within definite foramina or canals (Figure 10(B))

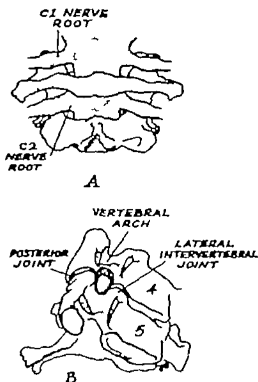


FIGURE 10. Intervertebral foramina (A) First and second nerve roots have no foramina. (B) Typical foramen showing the boundaries of a nerve root.

Bovill,[3] in 1950 attempted to refute the existence of these lateral interbody joints as true synovial joints However a study of gross specimens reveals the presence of articular cartilage on the adjacent surfaces of the upward posterolateral projections and the beveled inferior areas of the vertebral bodies. The medial boundary of these articular areas is the intervertebral disc, and a well defined capsular

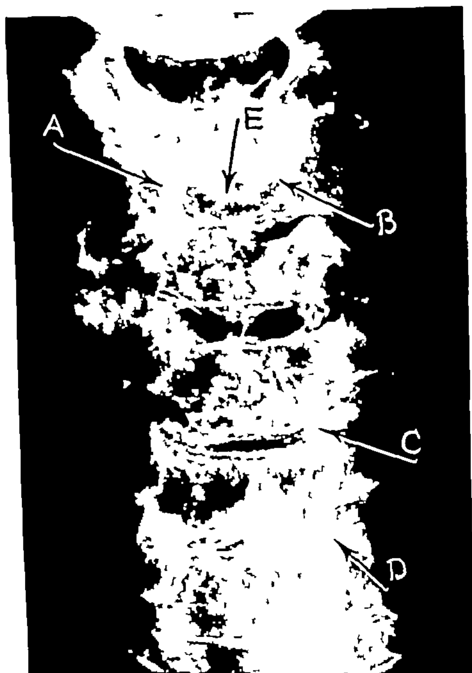


FIGURE 12 Arthrograph of a cervical spine Radio-opaque material was injected into the lateral interbody joints at (A) (B) (C) and (D) The material has remained within the joints at (A) (B) and (C) At (D) the material has spread into the crevices of the degenerated disc. The material was injected into the disc at (E)

radiographs were made of the specimen. Marked degenerative changes of the disc between the sixth and seventh vertebrae can be seen. Here the radio-opaque material has spread through the crevices of the disc, indicating that marked degenerative changes in a disc disrupt the medial boundaries of the corresponding interbody joints. Later dissection of this area revealed the marked degeneration of the disc and of the interbody joints. The articular surfaces of the joints presented a typical gross picture of chondromalacia, and there were spur formations at the margins of the joints

These joints are of great significance in the mechanism of cervical nerve root irritation because of their close proximity to the nerve roots as they pass through the intervertebral canals (Figure 10(B))

The author prefers to call these articulations between the posterolateral surfaces of the bodies of the vertebrae the lateral intervertebral joints" or the lateral interbody joints to distinguish them from the posterior or apophyseal joints. It is possible that these interbody joints are evolutionary remnants of the synovial joints between the cervical vertebrae of lower vertebrates such as birds They do not occur in the Canidae but they are present in the Primates.

BODIES OF THE CERVICAL VERTEBRAE

The bodies of the cervical vertebrae are flat posteriorly between the lateral intervertebral joints, whereas the anterior surfaces are curved with the inferior margins jutting downward (Figure 13)

The vertical diameter of the posterior portion of the bodies is slightly greater than the vertical diameter of the anterior portion This is a contributing factor in the difference between the vertical diameter anteriorly and posteriorly of the intervertebral discs To assure a forward curve of the cervical spine it is necessary that the vertical

posterior surface of the body of the second cervical vertebra and a line A′ B′ drawn parallel to the posterior surface of the body of the seventh cervical vertebra intersect each other at the level of the interspace between the fourth and fifth vertebrae. This indicates that the point of greatest stress and strain occurs at the level of the fourth and fifth articulations in hyperextension In the flexed position the line AB and the line A′ B′ intersect each other at the level of the interspace between the fifth and sixth cervical verte-

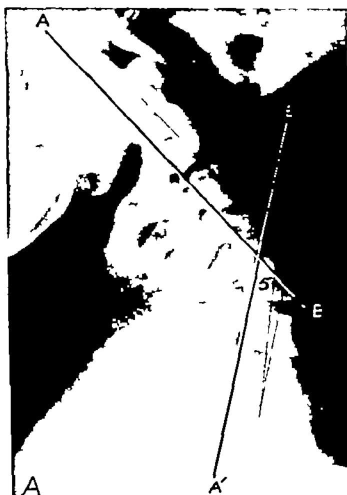


Figure 14A Areas of greatest stress and strain. Point of intersection of lines AB and A B indicates level of greatest stress and strain in hyperextension (A)

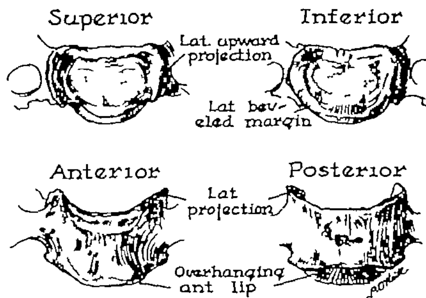


FIGURE 13 Vertebral bodies.

diameter of the anterior portion of the disc be two or three times greater than it is posteriorly (Figure 8)

AREAS OF GREATEST STRESS AND STRAIN

The joints between the sixth and seventh cervical vertebrae are the first freely movable joints above the dorsal area, but the joints between the sixth and fifth and between the fifth and fourth vertebrae are more vulnerable to stress and strain and to injury than are any of the other joints. This can be illustrated on lateral x ray films made with the neck in hyperextension and in flexion (Figure 14A&B) In the position of hyperextension the joints between the fourth and fifth vertebrae are at the apex of the forward curve of the cervical spine, whereas the joints between the fifth and sixth vertebrae are at the apex of the backward curve of the cervical spine when the neck is in flexion In the hyperextended position a line AB drawn parallel to the

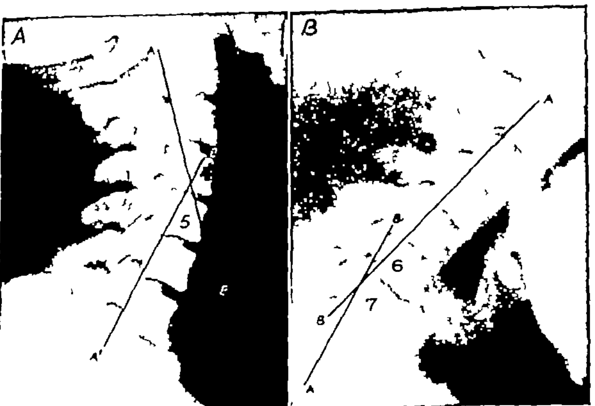


FIGURE 15 (A) and (B) Areas of maximum stress and strain altered by fixation of vertebrae Films (A) and (B) were made in 1946. Films (C) and (D) (See page 24) were made in 1953 Films (E) and (F) (See page 25) were made in 1957 Note progressive hypertrophic and degenerative changes and alteration in the points of maximum stress and strain as further fixation has occurred

brae, which indicates that the greatest amount of stress and strain occurs at this level when the neck is in flexion.

Limitation of motion of the cervical spine from muscle spasm or fixation however, will alter the point of greatest stress and strain depending on the degree and level of motion and the area of fixation. In Figure 15(A)&(B) it can be seen that there is degeneration of the intervertebral discs between C4 and C5, and C5 and C6 with narrowing of the discs and hypertrophic changes. In hyperextension the apex of the forward curve is at the body of C4 There



FIGURE 14B. Areas of greatest stress and strain. Point of intersection of lines AB and A'B indicates level of greatest stress and strain in flexion (B)

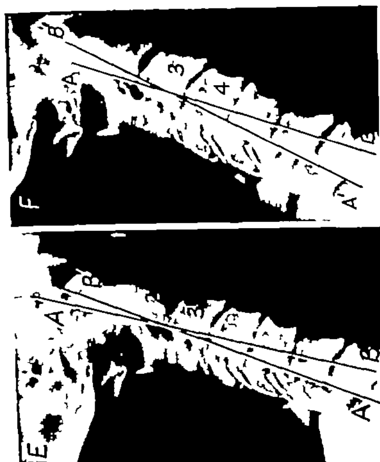


Figure 15 (E) and (F) (See legend page 23)

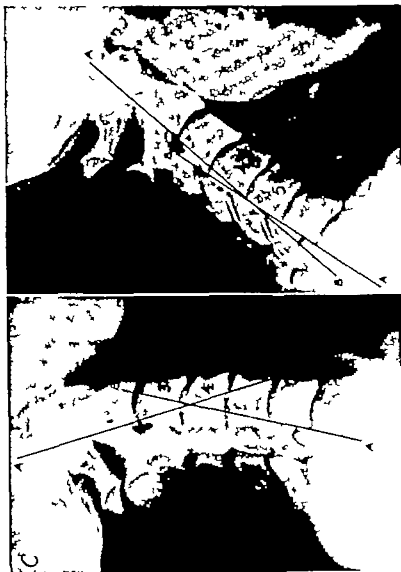


Figure 15 (C) and (D) (See legend page 23)

be considered under mechanism of cervical nerve root irritation.

The second cervical nerve, as it leaves the dura, passes

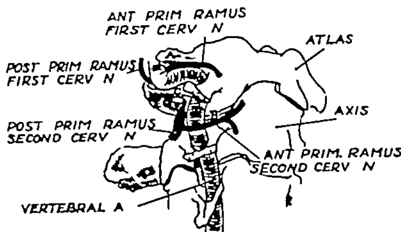


Figure 16. Relationships of first and second nerve roots.

laterally for a short distance of approximately one quarter of an inch Here it rests on the midportion of the medial margin of the atlanto-axial articulation It then follows the margins of this joint laterally and slightly downward. It lies beneath the posterior arch of the atlas until it turns posteriorly within the upper neck muscles. Its close proximity to the lateral joint and the posterior arch make it potentially vulnerable to irritation or compression as can be seen in Figure 16

The intervertebral foramina formed by the other cervical vertebrae are bony canals which are somewhat ovoid in shape and which have greater vertical diameters than anteroposterior diameters. The roofs and floors of the foramina are formed by the grooves in the roots of the adjacent vertebral arches The inferior groove of the proximal root is wider than the superior groove of the inferior root so that the roofs are definitely wider than the floors (Figure 10(B)) The posterior walls of the canals are formed by the adjacent posterior articular processes but primarily by the superior articular processes of the distal vertebrae The

is fixation of C4, 5 and 6 which decreases the backward curve when the neck is in flexion so that the point of greatest stress and strain falls at the level of C6 and 7 However as the degenerative processes progress one can see that the points of greatest stress and strain are altered again, and ligamentous instability is demonstrable above the area of fixation (Figure 15(C) and (D)) This may be due to sprain of the ligamentous and capsular structures at this area, as was true in this case, or it may be due to a compensatory mechanism resulting from an attempt by these joints to take over the function of the fixed areas of the neck.

Radiographs of this cervical spine made in 1957 illustrate further degenerative changes and fixation. The only demonstrable motion present occurs between the atlanto-occipital joints and perhaps a very minimal amount between the atlanto-axial joints The points of maximum stress and strain with further fixation have shifted upward (Figure 15 (E) and (F))

THE INTERVERTEBRAL FORAMINA

The absence of posterior articulations between the head and atlas and between the atlas and axis leaves the first two nerves without actual intervertebral foramina, as stated above. However their relationship to adjacent bony structures is important.

The first nerve root leaves the dura at right angles and the nerve passes immediately over the lateral portion of the posterior arch of the atlas. It lies directly beneath the vertebral artery for a short distance as the artery courses around the base of the lateral mass of the atlas to enter the dura It then lies behind the artery before it turns backward to supply the sub-occipital muscles (Figure 16) The superior articulation of the atlas overhangs the artery and nerve root posteriorly—an important anatomical fact to

be considered under mechanism of cervical nerve root irritation

The second cervical nerve, as it leaves the dura, passes

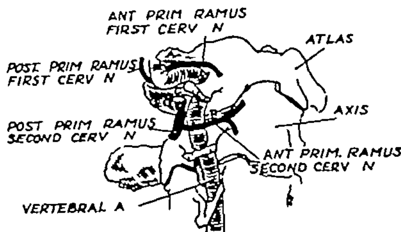


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laterally for a short distance of approximately one quarter of an inch. Here it rests on the midportion of the medial margin of the atlanto-axial articulation It then follows the margins of this joint laterally and slightly downward It lies beneath the posterior arch of the atlas until it turns posteriorly within the upper neck muscles. Its close proximity to the lateral joint and the posterior arch make it potentially vulnerable to irritation or compression as can be seen in Figure 16

The intervertebral foramina formed by the other cervical vertebrae are bony canals which are somewhat ovoid in shape and which have greater vertical diameters than anteroposterior diameters The roofs and floors of the foramina are formed by the grooves in the roots of the adjacent vertebral arches. The inferior groove of the proximal root is wider than the superior groove of the inferior root so that the roofs are definitely wider than the floors (Figure 10(B)) The posterior walls of the canals are formed by the adjacent posterior articular processes but primarily by the superior articular processes of the distal vertebrae The

anterior walls are formed by the lateral portion of the bodies of the adjacent vertebrae and the margins of the intervening interbody articulations. The anterior walls are of great significance from a mechanical standpoint, in as much as the nerve roots pass directly over and are in intimate contact with the margins of the lateral interbody joints. The gliding motion which occurs between these joints whenever the head and neck are turned or moved in any direction subjects the nerve roots to irritation if there is any mechanical derangement present.

The nerve roots lie on the floor of the canals and fill their anteroposterior diameter completely The upper one-eighth to one fourth of the foramina, or the canals, is filled with areolar and fatty tissues and small veins Small spinal arteries which are branches from the vertebral artery pass back through the intervertebral foramina to enter the vertebral canal. Minute branches from the spinal nerves, which are known as recurrent meningeal nerves, pass back through the intervertebral foramina, also

THE CERVICAL NERVES

The cervical nerves are formed by the union of dorsal and ventral fibers, or roots, which arise on the corresponding surfaces of the spinal cord These fibers, for the most part, leave the cord within the spinal canal on a level with the body of the corresponding vertebra This means that there is not usually a continuous flow of nerve fibers from the cord but a short interval between each group of fibers. These short intervals or spaces are on a level with the intervertebral discs.

Figure 17 is a sketch of the ventral and dorsal surfaces of the cervical spinal cord and the corresponding nerve roots. It can be seen that the upper fibers of each nerve root pass obliquely downward with decreasing degrees of obliquity to join the lower fibers at the lateral portion of the spinal canal where the ventral and dorsal fibers pierce

FIGURE 17 Ventral and dorsal nerve roots. Note intercommunication of nerve root fibers.

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VENTRAL NERVE ROOTS

Anterior median fissure

Dura mater

Arachnoid

Dural sheath of nerve

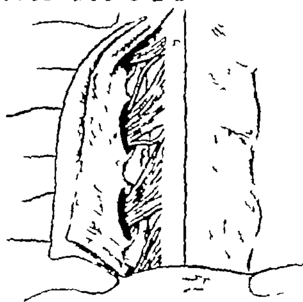


FIGURE 17 Ventral and dorsal nerve roots. Note intercommunication of nerve root fibers.

the dura mater separately Both sets of fibers are invested with a common dural sheath as they leave the spinal canal. The third to eighth, inclusive, enter the intervertebral foramina immediately As they enter the openings of the intervertebral canals they are at right angles to the cord. The ventral fibers, or the ventral nerve roots, are in intimate contact with the margins of the lateral intervertebral joints. The posterior fibers, or the posterior nerve roots, are in intimate contact with the posterior superior articular processes of the adjacent distal vertebrae.

Because of their close proximity to the anterior and posterior walls of the intervertebral foramina the cervical nerve roots are extremely vulnerable to compression or to irritation from any mechanical derangement or inflammatory condition in or about the foramina Such irritation or compression may cause pain and/or sensory and motor disturbances anywhere along the segmental distribution of the nerves.[19]

THE SYMPATHETIC NERVOUS SYSTEM

The sympathetic nervous system plays a definite role in the picture of cervical nerve root irritation, also The *cervical nerve roots are composed of motor and sensory* fibers only whereas the dorsal and upper two lumbar nerve roots contain white rami communicantes of the sympathetic nervous system as well. The cervical nerves have their connection with the sympathetic nervous system through the white rami communicantes of the upper two dorsal nerves which join the sympathetic trunk by way of their anterior primary rami and proceed upward to the cervical ganglia Gray rami communicantes or postganglionic fibers pass from the cervical ganglia to the anterior primary rami of the cervical nerves and are distributed with the divisions of the nerves. Other gray rami communicantes pass directly or indirectly to most of the cranial

nerves and peripheral branches pass to the pharanyx, to the heart as cardiomotor nerves, and to the arteries of the head, neck and arms (Figure 18).

Other postganglionic fibers make a communication with the recurrent spinal meningeal nerves before these nerves

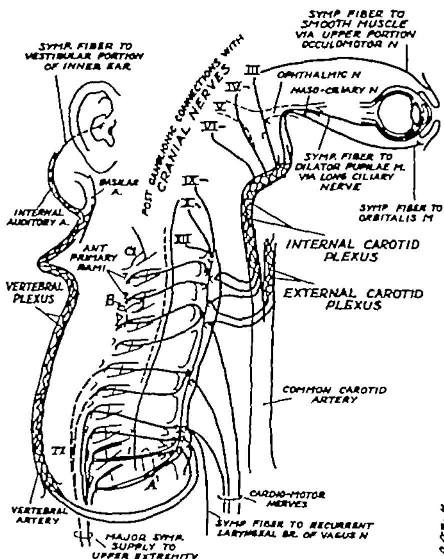


FIGURE 18. The cervical sympathetics. Preganglionic fibers – green. Postganglionic fibers – red. Interruption of preganglionic fibers at A will give paralysis of the cervical sympathetic supply. Irritation at B may cause reflex stimulation of the cervical sympathetics.

pass back through the intervertebral foramina to supply the dura and ligamentous structures (Figure 19)

The postganglionic fibers which invest the internal carotid artery give branches to the back of the orbit, the dilator muscle of the pupil and the smooth muscle of the

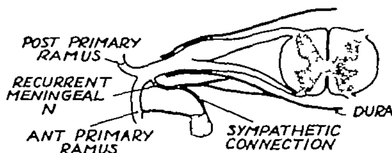


FIGURE 19 A recurrent spinal meningeal nerve and its sympathetic communication.

upper eyelid Still other postganglionic fibers which surround the vertebral arteries and its branches reach the vestibular portion of the ear (Figure 18) [8]

It must be remembered that pain-conducting afferent spinal nerve fibers from the blood vessels of the head neck and upper extremities traverse the sympathetic trunk and communicating rami, also [14]

In the consideration of cervical nerve root irritation these facts are of importance in as much as reflex stimulation of the sympathetics may give rise to symptoms and clinical findings which are secondary to irritation of the cervical nerve roots and *which at first thought may confuse the* picture

THE VERTEBRAL ARTERY

The anatomy of the vertebral artery should be considered in this study because of its close relationship to the cervical nerves and to the cervical vertebrae It is the first branch from the subclavian trunk It reaches the transverse foramen of the sixth cervical vertebra by passing upwards

and backwards between the scalenus anticus muscle and the lateral border of the longus colli muscle As it passes through the transverse foramina of the sixth to the second cervical vertebrae it lies directly anterior to the trunks of the cervical nerves and medial to the intertransverse muscles. As soon as the artery has passed through the transverse foramen of the atlas it turns sharply backwards and runs medially around the posterolateral aspect of the superior articular process of the atlas which overhangs it it then lies in the groove on the upper surface of the posterior arch of the atlas. It then enters the vertebral canal and runs upward through the foramen magnum into the cranial cavity where it pierces the arachnoid and passes to the lower border of the pons to unite with its mate from the opposite side to form the basilar artery *

The vertebral artery is vulnerable to injury throughout its course in the cervical area when any trauma to the cervical spine occurs. In as much as it is surrounded by a plexus of postganglionic sympathetic nerve fibers, injury to it may give rise to what might seem confusing symptoms.

THE DURA MATER SPINALIS

The dural covering of the spinal cord is firmly fixed at the margins of the foramen magnum to the second cervical vertebra and to the third cervical vertebra The distal portion of the dural covering blends with the filum terminale externum and extends downward to the back of the coccyx where it is fixed to the periosteum of this bone Normally it is not fixed to any other part of the spine and it is separated from the walls of the vertebral canal by a space called the cavum epidurale which is filled with soft fat and a plexus of thin-walled veins The spinal dura is, therefore, fairly free and its attachments do not interfere with the free movement of the vertebral column On either side the spinal nerve roots pierce the dura and carry with

them tubular coverings of the dura mater spinalis, which are called the dural sleeves of the nerve roots

Injuries or inflammatory reactions of the nerve roots or the adjacent structures may result in the formation of adhesions between the dural sleeves and the capsular ligaments adjacent to the nerve roots. The significance of this fact is important in the consideration of the mechanism of cervical nerve root irritation.

Chapter 3

THE MECHANISM OF CERVICAL NERVE ROOT IRRITATION

THE mechanism of cervical nerve root irritation can be understood easily if one keeps in mind this brief review of some of the pertinent anatomical facts concerning the cervical spine.

SUBLUXATIONS

The capsular structures and the accessory ligaments which include the supraspinous ligament, the ligamenta flava, and the anterior and posterior longitudinal ligaments have sufficient laxity to permit a normal range of motion in the joints of the cervical spine. Any undue laxness of these structures permits subluxations which produce alterations in the intervertebral foramina, which in turn may give rise to cervical nerve root irritation.

Posterior subluxations may occur with hyperextension of the neck and result in an anteroposterior narrowing of the midportion of the intervertebral foramina in this manner the postero-inferior margin of the beveled lateral portion of the body of the proximal vertebra approaches the anteromedial portion of the superior facet of the adjacent distal vertebra Compression of a nerve root occurs, therefore, anteriorly and posteriorly near its midportion as if it were being squeezed by a pincher A definite decrease in the vertical diameter of the intervertebral formania occurs, also with posterior subluxations (Figure 20(C))

A posterior subluxation may occur when the neck is

placed in hyperextension, if the spinous process of one vertebra overrides the adjacent distal spinous process. A lever like action occurs which forces the proximal vertebra posteriorly upon the distal vertebra

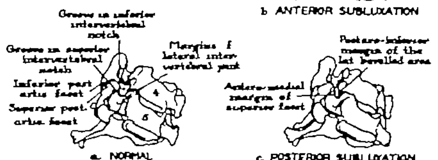


FIGURE 20 The effect of subluxations on the intervertebral foramina.

Anterior subluxations may occur when the neck is in flexion and cause anteroposterior narrowing of the foramina, also but to a much less extent. The anteromedial margin of the inferior facet of the proximal vertebra approaches the posterolateral edge of the lateral projection at the side of the body of the adjacent distal vertebra However in this instance there is not the same pincher effect as in the posterior subluxations in as much as the compression forces do not approximate each other in the same plane or direction. There is an actual increase in the vertical diameter of the intervertebral foramina with the neck is flexion (Figure 20(B)) [9-12]

Slight alteration in the intervertebral foramina occurs in rotation and lateral bending of the neck and these move

ments may aggravate the symptoms of cervical nerve root irritation

FORAMINAL SPURS

Degenerative changes about the posterior articular processes and the lateral intervertebral joints with the formation of hypertrophic spurs or osteophytes cause further compression of the nerve roots. This is more marked when subluxations occur or with extremes of hyperextension and flexion of the neck However hypertrophic spurring about these joints does not in itself indicate irritation of the cervical nerve roots in as much as these changes take place over a long period of time and motion between these joints becomes limited gradually The nerve roots, therefore, have an opportunity to adjust themselves somewhat to their narrowed foramina In other words, the nerve roots are able to tolerate the narrowing of their

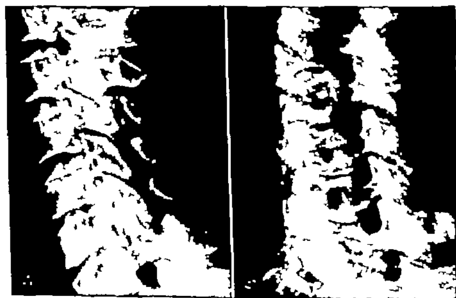


FIGURE 21 Lateral x-ray view (A) of a specimen which appears to have spur formations on the posterior margins of the vertebral bodies of C5 and 6 Oblique view (B) shows narrowing of the intervertebral foramen by the formation of spurs at the margins of the lateral interbody joint. Dissection of this specimen revealed no spur formations on the posterior margins of the vertebral bodies.

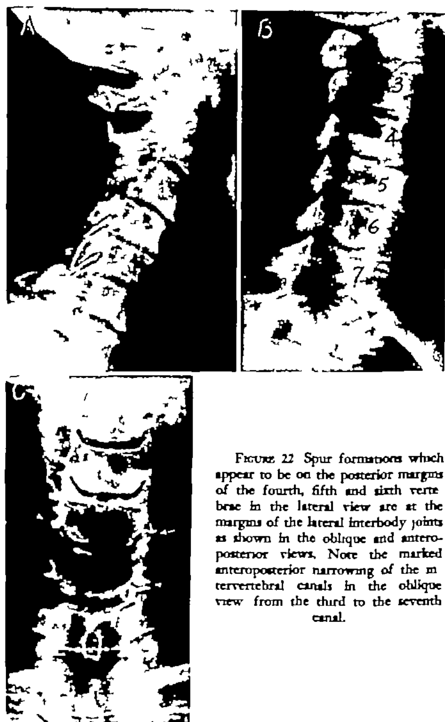


Figure 22 Spur formations which appear to be on the posterior margins of the fourth, fifth and sixth vertebrae in the lateral view are at the margins of the lateral interbody joints as shown in the oblique and anteroposterior views. Note the marked anteroposterior narrowing of the intervertebral canals in the oblique view from the third to the seventh canal.

canals which occurs slowly over a long period of time until some other insult occurs such as injury, ischemia, chemical or inflammatory changes.

The most marked hypertrophic changes occur about the margins of the lateral intervertebral joints and about the posterior joints. Hypertrophic changes and spur formations at the margins of the intervertebral disc joints posteriorly are not found usually, although the lateral x-ray films may give that impression (Figures 21 and 22)

These changes at the margins of the lateral intervertebral joints may occur on one or both sides and may involve joints at more than one level They are found to occur most frequently between the fifth and sixth and the fourth and fifth vertebrae, which are the joints most vulnerable to stress and strain and to injury However, they may occur at any level (Figure 23)

X-ray films, however do not reveal the true condition

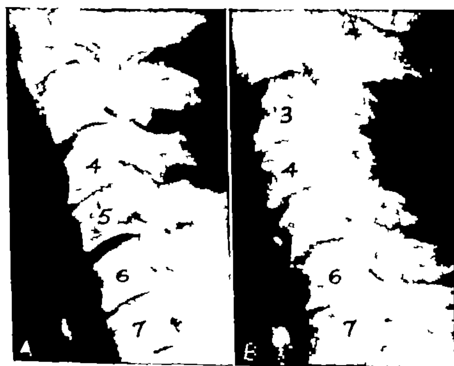


FIGURE 23 Hypertrophic changes and narrowed intervertebral discs at various levels.

nor the extent of the changes. Frequently radiographs are considered to be normal when there is definite pathology present. Figure 24A is a lateral view of a cervical spine which shows a pin placed in the lateral intervertebral joint posteriorly. Figure 24B is a semi-oblique view which shows the lateral intervertebral articulation and the position of the pin within the joint. Dissection of this specimen revealed that there was marked bulging posterolaterally of this joint. The articular surfaces showed marked chondromalacic changes, and there were marginal spurs present which accounted for the bulging of the joint. Similar changes were present between the fourth and fifth vertebrae in this specimen. Certainly the radiographs do not indicate the extent of the pathology which was present.

By the time foraminal spurs can be demonstrated radiographically the amount of foraminal narrowing is much greater than can be seen due to the marked hypertrophy or thickening of the capsular ligaments. The nerve roots in these narrowed canals may become flattened to conform to the anteroposterior narrowing of the foramina or they may be crowded into the distal part of the canals to avoid the foraminal encroachment. Adhesions form between the dural sleeves of the nerve roots and the adjacent structures so that extremes of neck motion produces a pull or tug upon the dural sleeves of the nerve roots to add further irritation of the nerve roots.[19]

FRACTURES

Compression or irritation of a nerve root may be caused by various types of fractures of the cervical vertebrae. Swelling and hemorrhage into the joints or displacement of a fragment of bone may be responsible for foraminal narrowing. A fracture of a posterior facet or of a vertebral arch causes a mechanical derangement of the intervertebral canals (Figure 25(A)&(B)). These fractures are often



FIGURE 24A. Lateral x-ray of a specimen. A pin was placed in the posterior portion of the lateral intervertebral joint in (A). Position of pin can be seen within the joint in (B).



FIGURE 24B Semioblique x-ray of specimen. A pin was placed in the posterior portion of the lateral intervertebral joint in (A) Position of pin can be seen within the joint (B)

difficult to demonstrate in the usual radiographs, and frequently they cannot be seen in films made immediately following an injury Flexion-oblique views and lateral-oblique views to show the posterior facets are necessary to demonstrate these fractures.

Crushing fractures of the vertebral bodies may cause backward displacement of the posterior fragment to alter the intervertebral foramina as well as the vertebral foramen Such a displaced fragment may cause pressure upon the spinal cord and upon the origin of the nerve root fibers (Figure 25C)

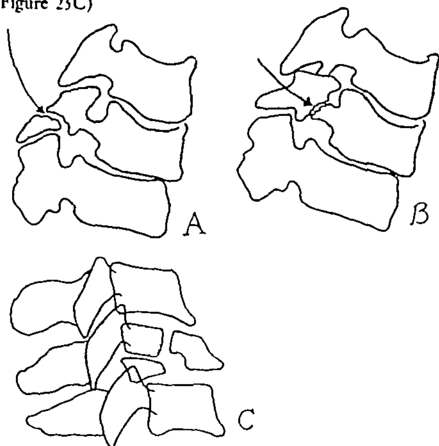


FIGURE 25 A fracture of a posterior facet (A) or of a vertebral arch (B) permits forward luxation of the involved vertebra and causes marked derangement of the intervertebral canals formed by that vertebra and the contiguous vertebrae. A posteriorly displaced fragment of a vertebral body causes narrowing of the intervertebral foramina and of the vertebral foramen (C)

Fractures of the lateral superior facets and of the posterior arch of the atlas may cause compression of the first nerve root and of the vertebral artery Fracture of the facets of the atlanto-axial articulation and of the lamina of the axis may cause irritation of the second nerve root (Figure 26) The close proximity of the vertebral arteries to the lateral masses of the atlas and to the superior facets of the axis makes these arteries extremely vulnerable to injury when fractures occur at these areas

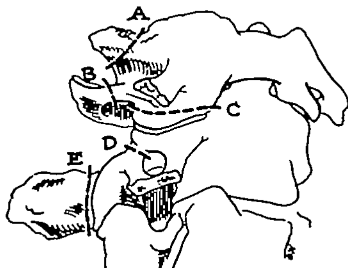


FIGURE 26. Fractures of the atlas and axis which may cause nerve root compression. (A) Fracture of superior facet of atlas may cause pressure on C1 nerve root. (B) Fracture of the posterior arch of the atlas may cause compression of either C1 or C2 nerve root. (C) Fracture of the inferior facet of the atlas may cause irritation of C2 nerve root. (D) Fracture of the superior facet of C2 may irritate C2 or 3 nerve root. Fractures of the lamina of the axis (E) may produce swelling and hemorrhage with irritation of C2 and 3 nerve roots.

DISLOCATIONS

Dislocation of one vertebra upon another without any fracture of the posterior structures occurs in rare instances. A certain amount of cord compression and of nerve root

compression is inevitable As the inferior facets are displaced forward over the superior facets of the adjacent distal vertebra the nerve roots may be compressed into the bottom of the intervertebral canals by the tips of the in ferior facets, or they may be compressed between the inferior facets and the upward lateral projections of the adjacent distal vertebra

THE ROLE OF THE CERVICAL DISC

All too frequently we hear the term cervical disc' used as a diagnostic term Usually this term is meant to convey that a cervical disc has been ruptured and that the disc material protrudes posterolaterally as in the lumbar area, to cause compression of a cervical nerve For the most part this is an erroneous impression which has developed because of the belief that the cervical nerve roots lie immediately posterior to the intervertebral discs. This relationship does not exist Extrusion of disc material laterally or posterolaterally would have to occur through the lateral interbody articulation which is very unlikely

As shown in Figure 27A, the fibers of the cervical nerve roots leave the cord at the level of the corresponding vertebral body The most proximal fiber of each nerve root leaves the cord at the level of the inferior margin of the disc above it and the lower-most fiber of each nerve root leaves the cord well above the margin of the disc below it. In as much as the nerve root fibers converge with decreasing obliquity to leave the spinal dura and the vertebral canal at their lateral extremes, they are well protected from the intervertebral discs by a safety zone" which is the posterior portion of the corresponding vertebral body They leave the safety zone" as they leave the spinal canal at right angles to pass immediately into the intervertebral canals. Here they are in intimate contact with the lateral interbody joints and the posterior joints, and by virtue of their posi tion between a potential pincher they are extremely vul-

nerable to insult on even the slightest derangement of their bony canals.[11]

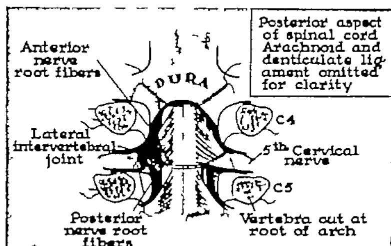


FIGURE 27A. The "safety" zone for the nerve roots. The nerve roots do not pass over the intervertebral discs. The ventral fibers rest upon the lateral interbody joints, as they make their exit from the spinal canal to enter the intervertebral canals. The body of the corresponding vertebra is their protection.

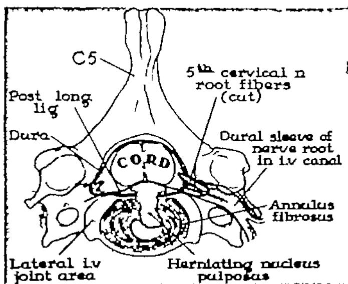


FIGURE 27B Posterior rupture of a cervical disc. The cervical nerve roots are protected by the bodies of the vertebrae, and a posterior herniation will result in cord compression rather than nerve root compression.

It is possible for disc material to be extruded posteriorly, but in this instance the material would cause compression of the spinal cord itself and would give rise to symptoms of cord compression (Figure 27B) A relatively large amount of disc material would have to be extruded posteriorly in order to cause compression of the nerve roots, and, as stated this would cause compression of the cord as well In this instance the symptoms could be greatly aggravated by flexion of the neck

Extrusion of disc material is much less likely to occur posterolaterally or posteriorly in the cervical area than in the other areas of the spine. This is true for the following reasons

First, the intervertebral discs do not extend to the posterolateral margins of the vertebral bodies because of the posterolateral articulations between the bodies of adjacent vertebrae. These joints are so placed that they take much of the strain off the intervertebral discs, and they are therefore, much more vulnerable to injury and to degenerative changes than are the cervical discs

Second the posterolateral projections at the superior surfaces of the vertebral bodies extend further posteriorly than they do anteriorly They are definitely cupped posteriorly so that they serve as a barrier to posterolateral extrusion of disc material (Figure 13)

Third, the posterior longitudinal ligament in the cervical area is denser, stronger and wider than in the other areas of the spine. It is composed of two distinct layers, a deep layer and a superficial layer in contradistinction to its structure below the cervical area The deep layer extends from the body of one vertebra across the annulus fibrosus to the body of the next vertebra It is narrow at the center of the vertebra and somewhat wider as it crosses the annulus fibrosus The posteromedial fibers of the capsular ligaments of the lateral intervertebral joints seem to take some origin from this deep layer This gives this portion of the posterior

nerable to insult on even the slightest derangement of their bony canals.[13]

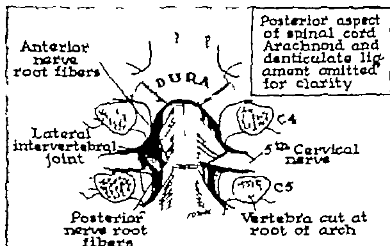


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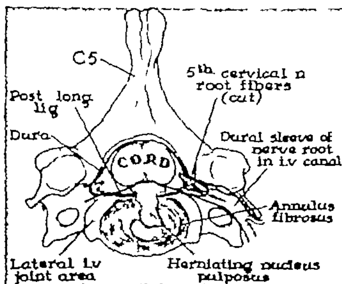


FIGURE 27B Posterior rupture of a cervical disc The cervical nerve roots are protected by the bodies of the vertebrae, and a posterior herniation will result in cord compression rather than nerve root compression.

longitudinal ligament a somewhat denticulated appearance which resembles the entire ligament of the thoracic and lumbar areas The superficial layer extends vertically from the skull downward across the vertebral bodies and intervening discs, and laterally to the intervertebral foramina or to the vertebral arches It is tightly adherent to the structures which are anterior to it (Figure 28)

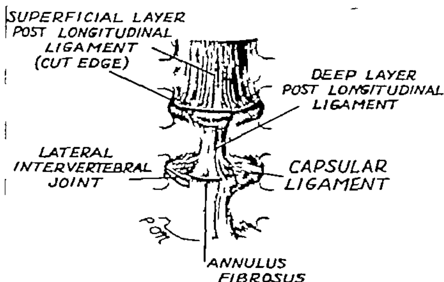
Fourth the nucleus pulposus in the cervical discs is placed nearer the anterior margin of the discs than the posterior so that the annulus is thicker posteriorly in its anteroposterior diameter than it is anteriorly (Figure 9)

Fifth the vertical diameter of the cervical discs is greater anteriorly than posteriorly and the discs have a much wider exposure anteriorly between the margins of the vertebral bodies than they have posteriorly

The most likely exit for the nucleus pulposus of a cervical disc, or of disc material is at the point of least resistance which is anteriorly or anterolaterally but not posteriorly nor posterolaterally

Disc material might be extruded posteriorly however if there were undue relaxation weakness or an actual tear in the posterior longitudinal ligament, and in the annulus fibrosus This material might be forced upward or downward or even laterally so that some of the fibers of the ventral root might be compressed In this event there should be compression of the cord, as already stated.

Thickening of the capsular ligaments of the lateral intervertebral joints and spur formation at the margins of these joints may give the appearance of extruded disc material beneath or anterior to the nerve root It is the author s impression that the surgeon who sees and feels a bulging anterior to the nerve root may be misinterpreting this as a posterolateral disc extrusion in many instances Even in the dissecting room one s first impression may be that these changes about the lateral intervertebral joints represent lateral disc extrusions until one cuts and retracts the nerve



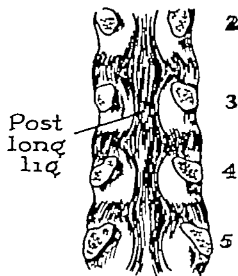


FIGURE 28. The posterior longitudinal ligament. (A) Cervical portion composed of deep and superficial layers. (B) Lumbar portion composed of one layer which is denticulated.

narrowing of the disc space between the fifth and sixth vertebrae, but did not show the compression fracture

OTHER FACTORS

Other mechanical compressions of the nerve roots within the intervertebral foramina may occur from swelling of the capsular structures of the lateral intervertebral joints and of the posterior joints. Swelling of the dural sheath of the nerve roots and hemorrhage may cause compression Swelling of the nerve roots themselves may occur as a result of sudden traumatic compression within the intervertebral canals. Adhesions occur as a result of trauma or inflammatory reactions and the dural sheaths of the nerve roots may become firmly adherent to the adjacent structures of the intervertebral canals.

Congenital anomalies may be responsible for nerve root irritation in some instances. Variations in the size and shape of the articular processes and in the angle of inclination of their articular surfaces may alter the anteroposterior diameters of the foramina Overton called attention to the variations in the posterior articular processes of the second and third vertebrae as a causative factor in irritation of the third cervical nerves[33] Congenital fusion of two or more vertebrae occurs in a small per cent of cervical spines Such fixation of vertebrae may be responsible for mechanical changes adjacent to the fused area due to the increased stress and strain placed upon the adjacent joints (Figure 29) as they atempt to take over the function of the fixed vertebrae.

The vertebral artery as it traverses the transverse foramina anterior to the nerves may be drawn backward when the neck is in hyperextension toward the superior margin of the articular process of the vertebra below and thus add further compression of the cervical nerves This will be more marked if sclerosis of the artery is present Compres

roots The true picture can then be seen Further dissection of these joints may reveal that similar protrusions or bulgings occur at the anterior portion of the lateral intervertebral joints When the joints are completely exposed they have the appearance of chondromalacia as seen in other synovial joints, with the typical moth-eaten areas in the contiguous articular surfaces. Still further dissection will reveal that the nucleus pulposus, in some instances, has remained within the confines of the annulus fibrosus in spite of the presence of degenerative changes in the disc and of narrowing of the intervertebral space.

It is the author's opinion that the so-called "hard discs," which were originally described by Stookey [17] and which were thought to be chondromas, are in reality degenerative changes about the posterolateral interbody joints with spur formations at the margins of the joints which are covered by thickened or hypertrophied capsules.

The dissection of twenty cervical spines, the radiographs of which showed from one to three narrowed discs, has revealed no instance of extruded disc material posterolaterally or posteriorly All specimens showed hypertrophic changes with spur formations at the margins of the lateral intervertebral joints at the level of the narrowed discs. In many instances the lateral joints immediately above or below the narrowed discs showed similar hypertrophic changes. Some specimens showed changes on one side only In some instances hypertrophic changes were found at various levels In one spine there was evidence of hemorrhage into the lateral interbody joint on one side which extended into the disc A saggital section showed marked irregular compression of the left superolateral portion of the sixth vertebral body Microscopic examination revealed an area of fragmentation of osseous tissue with beginning degenerative changes, probably representing a compression fracture The radiograph of this specimen showed slight

narrowing of the disc space between the fifth and sixth vertebrae, but did not show the compression fracture

OTHER FACTORS

Other mechanical compressions of the nerve roots within the intervertebral foramina may occur from swelling of the capsular structures of the lateral intervertebral joints and of the posterior joints Swelling of the dural sheath of the nerve roots and hemorrhage may cause compression Swelling of the nerve roots themselves may occur as a result of sudden traumatic compression within the intervertebral canals. Adhesions occur as a result of trauma or inflammatory reactions and the dural sheaths of the nerve roots may become firmly adherent to the adjacent structures of the intervertebral canals

Congenital anomalies may be responsible for nerve root irritation in some instances. Variations in the size and shape of the articular processes and in the angle of inclination of their articular surfaces may alter the anteroposterior diameters of the foramina. Overton called attention to the variations in the posterior articular processes of the second and third vertebrae as a causative factor in irritation of the third cervical nerves[23] Congenital fusion of two or more vertebrae occurs in a small per cent of cervical spines Such fixation of vertebrae may be responsible for mechanical changes adjacent to the fused area due to the increased stress and strain placed upon the adjacent joints (Figure 29) as they atempt to take over the function of the fixed vertebrae

The vertebral artery as it traverses the transverse foramina anterior to the nerves may be drawn backward when the neck is in hyperextension toward the superior margin of the articular process of the vertebra below and thus add further compression of the cervical nerves This will be more marked if sclerosis of the artery is present Compres-

sion of the artery itself may occur in this position, especially if spur formation is present at the lateral most margins of the lateral intervertebral joints, or if there are adhesions about the artery (Figure 30) Actual constrictions of the vertebral arteries may occur at any level, but the most frequent sites are above the level of the third vertebra where the arteries are very vulnerable to trauma Lewis and Coburn[19] have shown obstructions in the vertebral arteries, by vertebral angiograms, with changes in the position of the head

The mechanism of reflex stimulation of the cervical sympathetics must always be considered in nerve root irritation. In as much as irritation of the nerve roots may cause pain anywhere along the segmental distribution of the nerves, and in as much as such irritation causes muscle spasm and vasomotor ischemia the pain reflex may be aggravated Injury or sprain of the ligamentous and capsular structures gives rise to pain and may give rise, also, to reflex stimulation of the postganglionic fibers of the cervical sympathetics. If the pain is not relieved it may become a self-perpetuating pain stimulus as occurs in Sudeck's atrophy [14] Evans has called this phenomenon reflex sympathetic dystrophy [16] Reflex stimulation of the sympathetics can therefore, give rise to many signs and symptoms which occur secondarily to irritation of the cervical nerve roots. Such symptoms include blurring of vision dilatation of the pupil loss of balance, headaches, swelling and stiffness of the fingers, tendinitis and capsulitis [1]

In as much as vasoconstriction may result from reflex stimulation of the cervical sympathetics and cause aggravation of pain interruption or paralysis of the sympathetics may relieve pain by the relief of vasoconstriction or by paralyzing the afferent pain conducting spinal nerve fibers which traverse the sympathetic trunk

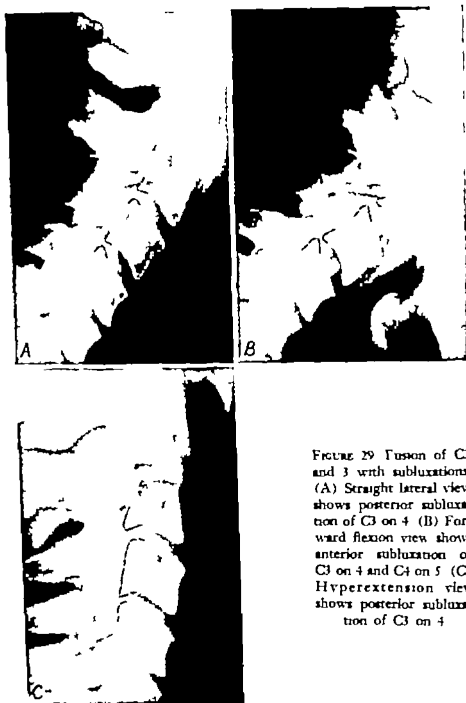


FIGURE 29 Fusion of C2 and 3 with subluxations. (A) Straight lateral view shows posterior subluxation of C3 on 4 (B) Forward flexion view shows anterior subluxation of C3 on 4 and C4 on 5 (C) Hyperextension view shows posterior subluxation of C3 on 4

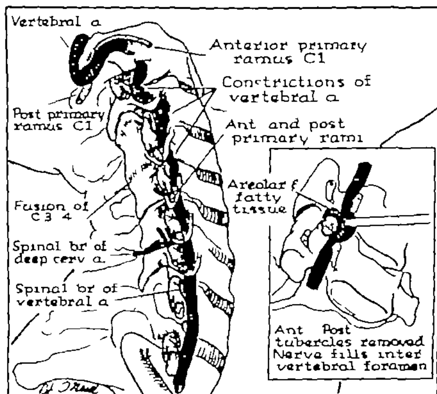


FIGURE 30 The vertebral artery—a sketch which shows the relationship of the adjacent structures, and actual constriction of the artery at three levels.

LOCATION AND DEGREE OF IRRITATION

The symptoms and clinical findings of nerve root irritation may vary somewhat due to the different sites of localized compression as well as the degree of compression of the nerve roots Sunderland, of the University of Melbourne, has classified nerve injuries on the basis of the degree of changes induced in the normal structure of the nerve. He states that, some fibers in the nerves may escape involvement while others sustain a variable degree of damage. The nature of the peripheral defect, the course of recovery and the end result depend on the particular fibers involved and on the particular type or degree of injury sus-

tained by each Nerves may be injured by mechanical, thermal, and chemical means as well as by ischaemia"[33] He believes that there are individual variations of susceptibility of nerve fibers to injury, and that some nerve fibers within a nerve are much better protected than others.

In considering the mechanics of nerve root irritation one must keep in mind that marked derangements may cause minimal symptoms whereas apparently insignificant derangements may cause severe nerve root irritation or compression This is illustrated in an x-ray film of a cervical dislocation which had been present for ten days before treatment was instituted (Figure 31A) Skull traction did not reduce the dislocation This man had only minimal symptoms. Figure 31B is an x-ray film of a cervical spine which shows only minimal derangement This man had severe pain in the shoulder, arm and chest with definite muscular weakness of the extensor muscles and definite sensory changes

In summary it can be said that it is within or about the intervertebral foramina that we must expect to find irritative or compressive factors which give symptoms and findings of nerve root involvement



FIGURE 31A. Extent of mechanical derangements is no indication of severity of symptoms. (A) Dislocation of C5 on 6 – marked derangement with minimum symptoms.



FIGURE 31B Narrowed disc between C5 and 6—minimum derangement with severe symptoms.

Chapter 4

ETIOLOGY

THE great mobility of the cervical spine and its vulnerable position between the relatively immobile thoracic spine and the head which must be balanced upon it and held in position by the supporting structures make it more susceptible to injury than any other part of the spine It is the author s opinion based on the study of some twenty five hundred cases, that ninety per cent of patients who have evidence of cervical nerve root irritation have had one or more injuries to the cervical spine, either recent or remote or both Ninety per cent of these patients have had a sprain type injury of the ligamentous and capsular structures, and the other ten per cent have had bony damage as well as sprain injuries.

Sprain of the cervical spine has been recognized and treated for some five thousand years as revealed by The Edwin Smith Surgical Papyrus.[4] Sprain of a cervical vertebra was described as an injury which has produced a rending forcing or wrenching apart of an articulation without a dislocation or an actual break. Sprain injuries were treated by wrapping the neck with fresh meat for twenty four hours, and then honey was applied until a recovery was complete

A sudden forceful movement of the head may cause a sprain injury Blows on the head or face, a sudden forceful pull on the arms such as occurs when roping steers, a sudden thrusting force on the arms a blow on the back of the neck and any fall which causes a sudden snapping of the neck may cause a sprain of the ligamentous and capsular

structures of the cervical spine, with immediate or delayed compression or irritation of the cervical nerve roots The most frequent trauma to the neck is caused by the whip-lash injury

THE WHIP LASH INJURY

Davis used the term whip-lash injury to designate a sprain of the ligamentous and capsular structures of the cervical spine[8] He believed that such an injury occurred as a result of a head-on collision of automobiles. This causes a sudden hyperflexion of the neck followed by a spontaneous extensor recoil. However the author has found that the greatest number of whip-lash injuries occur to innocent and unsuspecting passengers in automobiles, usually stopped at traffic signals, which are rammed in the rear by other cars or trucks. In this instance a sudden hyperextension of the neck occurs followed by a spontaneous hyperflexion recoil (Figure 32) The lashing force may come from the side as well

The sudden stopping of a moving vehicle may cause a whip-lash of the neck of the passenger who is unaware of the necessity for the sudden deceleration. Power brakes may be responsible for the avoidance of collisions, but they can be hazardous for the unprepared passengers.

High powered engines which enable a rapid acceleration of vehicles may be responsible for the lashing of the necks of the passengers.

The safety belt is of no value in preventing the lashing effect upon the neck. Headrests[23] may be of some value in preventing the hyperextension phase of the whip-lash but they have no protective value against the forward flexion and lateral phases Such devices give false security for the cervical spine. Only careful and watchful driving and riding can assure the safety of people who drive and ride in moving vehicles of this era

The weight of the head which is from six to eight

pounds on an average, increases the lashing effect, especially when the muscular control is caught off guard as usually happens in neck-lashing injuries. The patients describe the injury frequently as a popping or snapping of the neck.

The whip-lash injury causes a sprain of the ligamentous and capsular structures, or a wrenching apart of the joints by stretching, tearing or avulsion of the connecting structures In some instances actual luxations, fractures and disruption of the confining structures of intervertebral discs may occur

The hyperextension phase of the whip-lash may tear the anterior longitudinal ligament, and not infrequently a piece of bone may be avulsed from the margins of the vertebral bodies Posterior subluxations of the vertebral bodies and of the posterior joints occur and the cervical nerve roots may be compressed or contused by the pincher-like mechanism which occurs in backward subluxations (Figure 20C)

In the hyperflexion phase of the whip-lash any or all of the posterior ligamentous and capsular structures may be sprained Avulsion of the tip of a spinous process may occur when the interspinous ligament or the supraspinous ligament is sprained In this phase especially the capsular ligaments of the posterolateral interbody joints are subject to sprain because of their relative shortness and lack of elasticity Fractures of the body of a vertebra may occur when the posterior soft structures are torn or sprained (Figures 54 & 55)

A lateral whip-lash sprains the capsular ligaments, the lateral portion of the longitudinal and interlaminar ligaments and the small intertransverse muscles. Fractures of the posterior facets, of the vertebral arches and of the upward lateral projections of the vertebral bodies may occur on the opposite side as these bones are forced together in lateral bending and rotation (Figure 66)

In all instances the intervertebral disc or discs may be injured

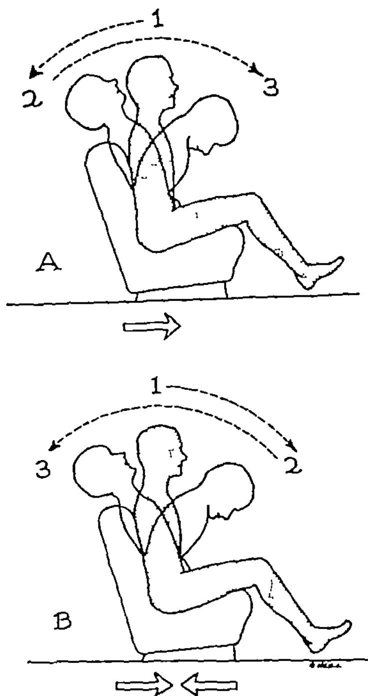


FIGURE 32 The whip-lash. (A) If car is hit in the rear the neck is thrown into hyperextension and then hyper flexion. (B) Head-on collisions cause sudden hyperflexion of the neck followed by a hyperextension recoil

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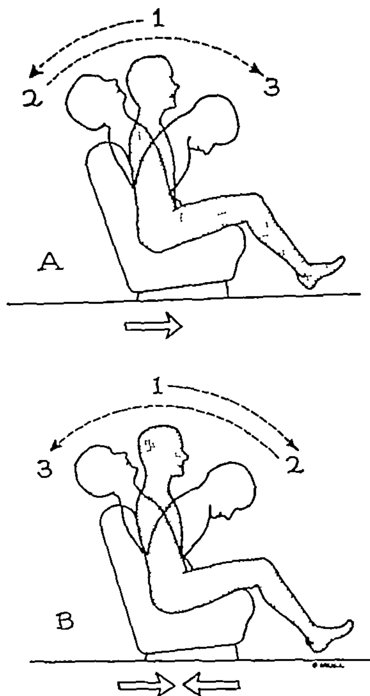


FIGURE 32. The whip-lash. (A) If car is hit in the rear the neck is thrown into hyperextension and then hyper flexion. (B) Head-on collisions cause sudden hyperflexion of the neck followed by a hyperextension recoil

Symptoms of nerve root compression may occur immediately or they may be delayed for hours, days or months. Often times the immediate symptoms may be so mild that they are ignored, but the following day the patient may have difficulty getting out of bed without assistance Stiffness of the neck and radicular pain may occur due to hemmorhage and swelling of the sprained structures and to irritation of the nerve roots

It has been suggested by Kaplan that the recurrent meningeal branch of the spinal nerve which has a connection with the postganglionic sympathetic fibers, may be compressed in the intervertebral foramen from sprain injury [14] This nerve supplies the posterior longitudinal ligament and the capsules of the lateral intervertebral joints The pain which results from sprain of the ligamentous and capsular structures themselves may be reflexly referred along the segmental distribution of the cervical nerves via the spinal meningeal nerves (Figure 19)

Hemmorhage within the sprained capsular structures which line the posterior and anterior walls of the intervertebral canals may give rise to the formation of adhesions between them and the dural sleeves of the nerve roots. Such fixation of the nerve roots within the canals may be responsible for delayed symptoms of nerve root irritation, especially with extremes of motion or following some apparently trivial accident

It is true that some sprains of the cervical spine give very few immediate symptoms. However these injuries initiate changes of a degenerative nature within the intervertebral discs, within and about the joints and within the ligamentous and capsular structures. The inevitable result is foraminal narrowing and eventual nerve root irritation. The nerve roots may be able to tolerate the gradual alteration of their canals for some time, and symptoms of nerve root irritation may be delayed until the nerve roots can no longer withstand further decrease in the size of their habitats A

very mild injury or a sudden movement may be sufficient to set off an irritative response which will be manifested by pain and disability

A sprain injury superimposed upon a cervical spine which shows radiographic evidence of previous injury as manifested by degenerative disc changes and joint changes will result in a greater disability than would occur to a normal spine. Luck in his book *Bone and Joint Diseases*, states Ligaments of an osteo-arthritic joint are more susceptible to a sprain than are ligaments of a normal joint The arthritic must perform his work with a measure of deliberation A quick movement may take a heavy toll' He states that the osteoarthritic joint, or the joint with degenerative changes has diminished tolerance and endurance, which of course makes it more susceptible to injury even on slight provocation.

The presence of fixation of two or more vertebrae, either congenital or acquired may give no appreciable disability until some unusual forceful stress is placed upon it, such as a whip-lash injury

All sprain injuries of the cervical spine result in some decrease in the functional capacity of this part of the spine The younger the victim the greater his reparative possibilities but even the youngster s neck will develop a decrease in its tolerance for the functional demands made upon it.

In most instances the symptoms are unilateral which can be explained, in part at least by the fact that the head and neck are normally held slightly tilted or rotated to one side so that the opposite side may receive the greater amount of injury or sprain. However symptoms may be bilateral or they may occur first on one side then on the other

UNILATERAL SUBLUXATIONS

Unilateral subluxations, which occur when the head is turned suddenly when a lashing of the neck occurs with the head turned to one side or when some unguarded sudden movement occurs, may give rise to cervical nerve root irritation. Many times such a subluxation occurs as a person who is asleep turns over in bed when the supporting structures are completely relaxed Acrobatic and football injuries often cause subluxations on one side

Some separation of the facets occurs which causes elevation of the vertebral body on that side and some forward displacement. This causes some narrowing of the intervertebral foramen on the opposite side However, pain and cervical nerve root irritation may occur on the side of the subluxation

By the same mechanism, impingement of the synovial membrane of a posterior joint may occur to give a similar clinical picture The swelling which occurs in the capsular *structures of the posterior joint and in the capsular struc*tures of the lateral interbody joint causes foraminal narrowing and compression of the adjacent nerve root in each instance

FRACTURES AND DISLOCATIONS

Fractures of the articular processes of the posterior or apophyseal joints and of the vertebral joints, with or without displacement, give rise to nerve root irritation If there is no displacement of the fragments the adjacent nerve root will be subject to irritation from hemorrhage and swelling immediately and later from callus formation at the site of the fracture or fractures. A compression fracture of the upward posterolateral projection of a vertebral body will give rise to irritation of the nerve root which lies upon it *for the same reasons*

If a fractured inferior facet or a fractured vertebral arch

is accompanied by displacement of its vertebral body, the nerve root adjacent to the fracture will be subject to irritation or compression due to the narrowing of its intervertebral canal (Figure 25 (A)&(B)) The nerve root immediately below the fracture will be subject to irritation, also, but to a lesser extent usually

Fracture of a lamina or posterior arch may be responsible for irritation of the posterior fibers of the adjacent nerve root but in this instance compression of the spinal cord is likely

Compression fractures of the vertebral bodies with splaying of the fragments cause anteroposterior narrowing of the vertebral canal and may cause compression or irritation of the ventral fibers of the nerve roots, as well as cord compression (Figure 25(C))

A fracture of the odontoid process may cause irritation of the ventral fibers of the second nerve roots and cord compression, which will be more marked if there is backward displacement of the atlas and the odontoid fragment

Dislocations forward of inferior facets upon the adjacent superior facets occur at times without any fracture of the facets A certain amount of cord damage is inevitable in this instance However compression of the adjacent nerve roots is caused by the displaced inferior facets as they impinge upon the intervertebral canals.

ABNORMAL LAXNESS OF JOINT STRUCTURES

Undue laxness of the ligamentous and capsular structures which may be part of a general debility or a long illness may be responsible for nerve root irritation especially with extremes of motion of the neck. Certain somatic types who have a generalized laxness of all joint structures may be prone to nerve root irritation in some instances Lateral radiographs of such cervical spines may show marked subluxations on extreme flexion and hyperextension

POSTURAL AND OCCUPATIONAL ATTITUDES

Postural and occupational attitudes which cause sudden or prolonged hyperextension of the neck may give rise to nerve root irritation even in the absence of demonstrable subluxations. Drooping of the shoulders results in hyperextension of the neck (Figure 33(A)) If one looks or reaches upward the neck must be hyperextended (Figure 33(B)) Stooping makes the head go backward unless one tries conscientiously to hold the neck in a straight position (Figure 33(B)) Some of the other daily activities and occupational attitudes which cause hyperextension of the neck are sitting at a table with the elbows resting on the table and the chin resting on the hands (Figure 33 (C)) lying down backward from a sitting position or sitting up suddenly from a supine position, shaving driving a car, using bifocal spectacles, hanging up clothes, making beds, working under cars or machinery painting and paper hanging

Many people of short stature develop a habit of elevating their chins and thus hyperextending their necks because this gives them a feeling of increased height, just as many tall people slump to lessen their height A marked dorsum rotundum gives rise to a compensatory increase in the forward curve of the cervical spine with resulting foraminal narrowing

Certain other daily activities or postural situations cause prolonged flexion of the neck which may give rise to nerve root irritation Typing bookkeeping writing sewing ironing cooking and washing dishes, reading in bed or in low lounge chairs, sleeping on thick hard pillows, and watching television are some of these activities (Figure 34)

DEGENERATIVE CHANGES

Degenerative changes, which are the inevitable response to ligamentous and capsular injuries, with the formation of

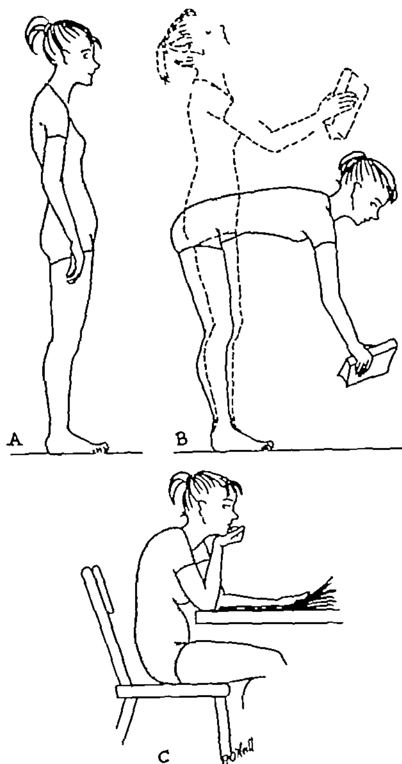


FIGURE 33 Postural attitudes causing hyperextension of the neck (A) Drooping shoulders. (B) Stooping (C) Usual "table posture" – chin on hand

marginal hypertrophic spurs or osteophytes about the lateral intervertebral joints and the posterior joints, cause foraminal narrowing, and are responsible for nerve root irritation of varying degrees

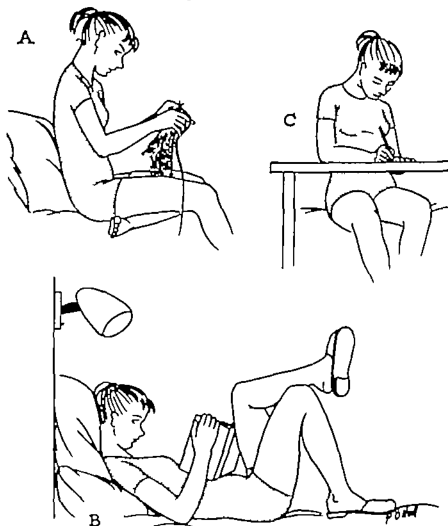


FIGURE 34 Postural attitudes causing flexion of the neck (A) Knitting or sewing (B) Reading in bed (C) Writing

Degenerative changes within an intervertebral disc occur if any of the confining components of the nucleus pulposus is injured Gradual narrowing of the disc takes place with a resulting decrease in the height and width of the adjacent

intervertebral canals. The changes which occur in and about the joints as a result of the altered dynamics and mechanics subject the nerve roots to irritation

Hypertrophic spurring does not occur on the true posterior margins of the vertebral bodies as a rule, but they may occur there following severe injuries to the posterior longitudinal ligament. When present they may give rise to symptoms and clinical findings of cord compression but not of nerve root irritation usually

The margins of the posterolateral interbody joints are the favored sites of hypertrophic spurs, and in some instances the spurs may be so extensive that they too give signs of cord compression as well as signs of nerve root compression

Encroachment and narrowing of the intervertebral canals by hypertrophic spurs may force the adjacent nerve root into the bottom of the canal. Such a nerve root may show varying degrees of compression depending upon its ability to survive in its restricted canal, and depending upon the functional demands made upon the cervical spine Perineural fibrosis is inevitable

As these hypertrophic changes develop varying degrees of fixation of the contiguous vertebrae occur which places a greater functional demand upon the joints above and below resulting in eventual degenerative changes of these joints and the possibility of irritation of the adjacent nerve roots. An excellent example of progressive hypertrophic changes and foraminal encroachment can be seen in Figure 35

INFLAMMATORY CONDITIONS

Inflammatory changes in or about the posterior joints and the lateral intervertebral joints may be responsible for irritation of the cervical nerve roots in approximately eight per cent of the cases

The changes accompanying rheumatoid arthritis may

cause foraminal narrowing but usually there is little if any bony encroachment of the intervertebral canals (Figure 36)

Gouty arthritis may give rise to inflammatory reactions in or around the joints of the cervical spine to cause irritation or compression of the cervical nerve roots within their canals In the chronic type, *foraminal narrowing may* be due to actual bony encroachment or to tophaceous formations (Figure 37)

Ankylosing spondylitis does not cause bony foraminal



FIGURE 35 Radiographs which illustrate progressive degenerative changes. This patient received a whip-lash injury in 1937 when a heavy truck hit the rear end of the car in which she was riding X ray films made immediately following the injury (A) and (B) were thought to be negative



FIGURE 35C

FIGURE 35C. The lateral view was made in 1945 following a second injury. Note the narrowing of the disc at 6 and 7 and the degenerative changes at this level. There is some narrowing of the disc between 5 and 6, also.

FIGURE 35D and E. In 1956, nineteen years later this patient received another whip-lash injury. Note the progressive degenerative changes which have occurred since the initial injury (D) and (E).





FIGURE 35D AND E



FIGURE 36. Radiographs of the cervical spine of a patient who has rheumatoid arthritis. Note the absence of bony encroachment of the intervertebral canals.

narrowing However the stress and strain placed upon the joints which escape ankylosis may cause changes which do give rise to nerve root irritation (Figure 38)

A certain type of ankylosing arthritis which involves fusion of the vertebral bodies anteriorly with marked proliferative changes may not cause bony encroachment of the intervertebral canals, but may give rise to nerve root irritation above or below the fused area (Figure 39)

Upper respiratory infections may give rise to actual inflammation of the cervical joints Swelling of the joints may accompany allergic reactions and hormonal imbalances. Toxic capsulitis or synovitis of an inflammatory nature may occur as the result of infectious processes elsewhere in the body

No doubt some of the joint changes of an inflammatory nature are due to actual biochemical alterations which may accompany osteoporosis. The actual irritative factor in some instances may be due to chemical changes or to some low grade infectious process within the nerve roots themselves.

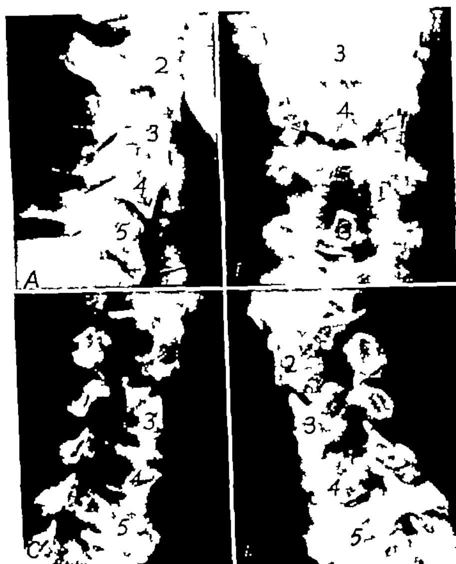


FIGURE 37 Radiographs of the cervical spine of a patient who has gouty arthritis. Arrows in (B) point to tophaceous deposits at the lateral interbody joints between 4 and 5 Note the anteroposterior narrowing of the intervertebral canals in (C) and (D)

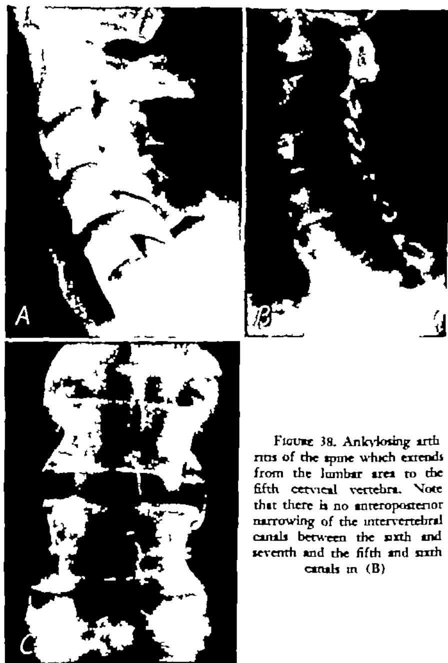


FIGURE 38. Ankylosing arthritis of the spine which extends from the lumbar area to the fifth cervical vertebra. Note that there is no anteroposterior narrowing of the intervertebral canals between the sixth and seventh and the fifth and sixth canals in (B)

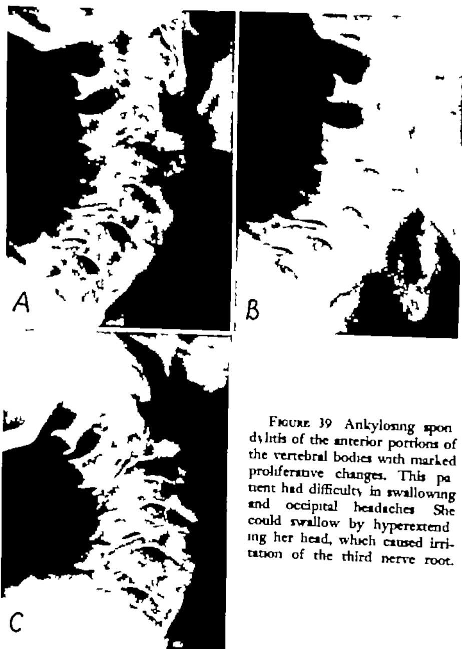


FIGURE 39 Ankylosing spondylitis of the anterior portions of the vertebral bodies with marked proliferative changes. This patient had difficulty in swallowing and occipital headaches She could swallow by hyperextending her head, which caused irritation of the third nerve root.

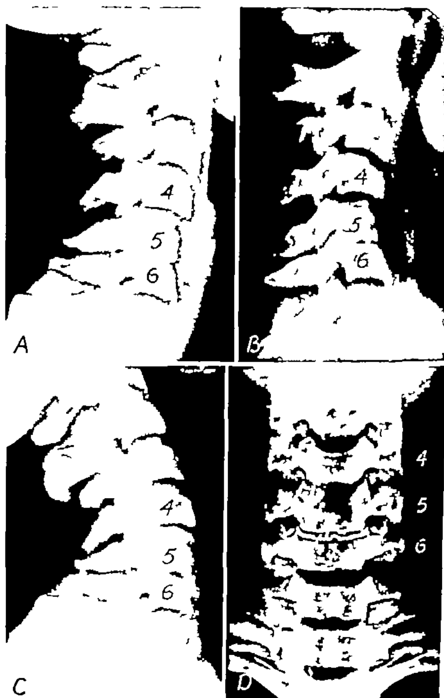


FIGURE 40 Radiographs of the cervical spine of a fourteen year old girl following a recent sprain injury of the neck. The bodies of the fifth and sixth vertebra are fused posteriorly probably a congenital fusion. Note the marked ligamentous instability between the fourth and fifth vertebrae

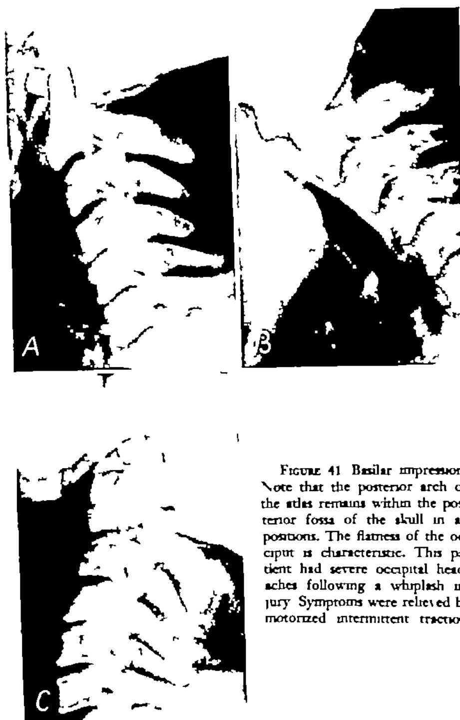


FIGURE 41 Basilar impression Note that the posterior arch of the atlas remains within the posterior fossa of the skull in all positions. The flatness of the occiput is characteristic. This patient had severe occipital headaches following a whiplash injury Symptoms were relieved by motorized intermittent traction.

ANOMALIES

Congenital fusion of two or more cervical vertebrae does not in itself cause nerve root irritation at the site of the fused area. The foramina may be smaller at this area, but they are round or oval in shape and their contour is smooth. However, the fixation of two or more vertebrae places an



FIGURE 42. Congenital anomalies of the atlas. Note the bony arches over the vertebral arteries and the first cervical nerve roots. This anomaly is due to calcification of the distal portion of the posterior atlanto-occipital ligament.

added strain upon the adjacent joints as they attempt to maintain the functional capacity of the neck, and the changes which occur in these joints may cause nerve root irritation or compression (Figures 29 and 40).

Basilar impression, which is an invagination of the upper cervical vertebra into the skull due to elevation of the floor of the posterior fossa of the cranium (Figure 41), may be responsible for nerve root irritation. However

symptoms may not appear until the third or fourth decade of life or until some apparently trivial injury to the neck occurs This condition, according to Hadley [10] may be an acquired one secondary to increased sclerosis of the base of the skull in Padget s disease. In some instances the upward migration of the cervical spine into the skull places traction upon the cervical nerves to cause symptoms of irritation of the nerve roots

A frequent anomaly of the atlas is the presence of a bony arch over the vertebral artery and the first cervical nerve root This arch represents ossification of the inferolateral margin of the posterior atlanto-occipital membrane (Figure 42) Following injuries to the upper part of the cervical spine, adhesions may form between the artery, the first nerve root and the bony arch or canal through which they pass

Cervical ribs do not, of course, cause nerve root irritation, although they have received credit frequently for symptoms of irritation of the nerve roots They may in rare instances be responsible for compression of the adjacent peripheral nerves, however

OTHER FACTORS

Many patients who have received whip-lash injuries have symptoms of a mild concussion of the brain, also [7] Without proper treatment psychogenic reactions may develop which aggravate the symptoms

Emotional stress and strain physical and mental fatigue cause nervous tension and anxiety The changes may be chemical or ischemic in nature, but certainly they are responsible factors in some instance of cervical nerve root irritation

Unnecessary or thoughtless roughness in handling a patient who is under a general anesthetic may result in injury of the ligamentous and capsular structures The com

plete relaxation of the supporting structures makes the joints vulnerable to sprain and the nerve roots to irritation

In order to complete the etiological picture one must mention the word *idiopathic*, which is the term used by the defeatist to signify "I don't know the cause." In many instances there may be no immediate demonstrable etiology However, if one searches diligently for the cause of any painful or abnormal condition the answer usually can be found

Chapter 5

DIAGNOSIS

THE diagnosis of cervical nerve root irritation is based on the history and symptoms and the clinical and x ray findings.

HISTORY AND SYMPTOMS

The important points in the history can be ascertained by following the outline of the history sheet used by the author (Figure 43) It is important to know the patient s

OCCUPATION ________________ AGE ________
DATE of INJURY ________ Type Auto ______ Fall ______ Other ______
SYMPTOMS Duration ________ Onset: Sudden ______ Gradual ______
PAIN Constant ________ Intermittent ______ Character ______
Head ______ Right ______ Left ______ Both Sides ______
Neck ________________ F Arm ________________
Sh. Joint ________________ Hand ________________
Arm ________________ Chest ________________
Others ________
STIFFNESS ________________
Neck ________________ Elbow ________________
Sh. Joint ________________ Wrist ________________
Fingers ________
BLURRING OF VISION ________ LOSS OF BALANCE ________
NUMBNESS & TINGLING ________ BLACK-OUTS ________
WEAKNESS OF ARM ________________ Hand ________
OTHER SYMPTOMS ________________
Shortness of Breath ________ Palpitations ________
Difficulty in Swallowing ________ Nausea ________
AGGRAVATION ________________
RELIEF ________________
PREVIOUS TREATMENT & DIAGNOSIS ________________

FIGURE 43 History form used by the author

occupation to determine whether or not his work requires long periods of hyperextension or flexion of the neck. The age of the patient is significant. Cervical nerve root irrita tion can occur at any age but the greatest percentage occurs in the third and fourth decades

The history of an injury may be difficult to obtain at first interrogation Injuries to the neck do not always give immediate symptoms and the patient may not realize that the neck has been injured How the injury occured is important. If the patient was involved in an automobile accident — was the car hit from the rear, in the front, or at the side The symptoms may have come on following a fall. Turning or jerking the head suddenly or turning over in bed may have been the immediate cause The symptoms may have been present for a few minutes to several years. The onset of the symptoms may have been sudden or gradual.

Usually the presenting symptom is pain and it is important to know whether it is constant or intermittent. The pain may vary in character from a burning sensation to a sharp knife-like pain. It may be of a dull aching or boring character It may be mild or an annoying type of pain, or it may be excruciating

Approximately sixty five per cent of all the cases complain of headache on one or both sides Usually the pain in the head starts at the back of the neck and radiates to the ears or forward to the top of the head or to the eyes. Frequently the patient states that the eyeball feels as if it is being pulled backward into the head This is due to reflex stimulation of the sympathetic nerve supply to the orbital muscle.

Pain in the neck on one or both sides is present in at least ninety per cent of all cases and pain on the right side occurs slightly more frequently than it does on the left side. The patient may have pain in or about the shoulder joint or between the shoulders Pain in the arm occurs usually in the midportion near the insertion of the deltoid muscle Pain in the forearm may be present in the extensor muscles or at their origin from the lateral epicondyle. Occasionally the flexor group may be painful Pain in the hand or wrist occurs occasionally Pain in the chest occurs

in approximately twenty-five per cent of the cases Pains in other locations supplied by the cervical nerve roots may be present and should be determined in taking the history

Stiffness of the neck occurs usually and the patient may complain of inability to turn the head to one side or he may complain of inability to flex or hyperextend the neck Often he states he has a 'crick in the neck Stiffness in the shoulder joint is a frequent complaint and may be of recent origin or of several days, weeks or months duration The patient may complain of inability to comb the hair get the hand in the hip pocket or fasten a brassiére Limitation of elbow motion may occur Occasionally the patient may complain of stiffness of the wrist and swelling of the fingers.

Blurring of vision is often noted by patients who have had recent injuries. The patient may have had his glasses changed without relief Loss of balance occurs in about fifteen per cent of the cases Usually the loss of balance is noticed when the patient first lies down or when he first gets up in the morning It may be aggravated by stooping getting up from a sitting position or by turning over in bed. The loss of equilibrium may be so severe that the patient cannot walk unassisted There is a tendency to fall to the side of involvement In this connection it has occurred to the author that Ménière s syndrome may be a part of the cervical syndrome in as much as the symptoms of equilibratory disturbances are very much the same and in both instances are due to reflex stimulation of the sympathetic nerve supply to the inner ear and to the eye

Twitching of the upper eyelid and excessive lacrimation may occur Recently a number of patients who have had whip-lash injuries have complained of transitory deafness

Numbness and tingling of the fingers occurs frequently and is usually more pronounced at night so that the patient may awaken with one or all fingers of the hand tingling

Numbness of one side of the tongue and of the face may occur

The patient may complain of a sensation of "blacking out Usually this symptom accompanies recent injuries high in the neck, although some patients with marked hypertrophic changes of the cervical spine complain of this sensation when the neck is suddenly hyperextended. Weakness of the arm is a frequent complaint and the patient states that the arm feels like a dead weight or he may say that his arm is useless Weakness of the grip is found in about fifteen per cent of the cases and often there is a tendency to drop things Twitchings of the muscles of the shoulder girdle and arms are not unusual complaints

Other symptoms that are encountered occasionally are shortness of breath, palpitations, difficulty in swallowing and nausea and vomiting One or all of the above symptoms may be present

It is important to know what aggravates the pain. The patient may have noticed that certain positions of the neck and head make the pain worse. Weather changes may aggravate the symptoms. The patient may or may not tell you that stooping lifting bending reading watching television etc make the pains worse If stooping causes anterior chest pain one must think, also of a diaphragmatic hernia. Often the pain is worse at night and the patient is unable to sleep Fatigue and emotional upsets aggravate the symptoms usually

It is important to know what gives relief Not infrequently the patient will tell you that changing positions gives some relief Sometimes the pain is relieved by the application of pressure to the painful area Heat is beneficial usually Many patients state that they live on Bufferin and aspirin "

Previous treatment should be noted A certain percentage of the patients will have had no treatment while others will have had many forms of therapy tried, and will have

been treated for many conditions other than irritation of the cervical nerve roots

Classification of Patients

Once the history has been taken it will be noted that the patients can be classified into one of five groups, depending upon the severity and duration of the symptoms

In the first group will fall those patients who have had a recent neck-lash injury with no history of any previous injury or symptoms

The second group of patients comprises those who have a so-called crick in the neck The pain is excruciating and is usually localized to one side of the neck The patient holds the head tilted away from and the chin turned toward the painful side. The neck is usually in slight flexion A diagnosis can be made as the patient walks into the office because of the characteristic position of the head Apparently there is a unilateral subluxation, or possibly an impingement of the synovial membrane of the joint. The patient usually awakens with a 'crick He may have turned over in bed or turned his head suddenly

The third group includes those patients who have had an injury several days, weeks or months previously The symptoms were mild at first or were thought to be of little significance However as motion of the neck is continued latent symptoms develop

The fourth group consists of patients who give a history of intermittent pain and stiffness over a period of years. These patients usually have gone from one doctor to another and have been labeled neurotics They have been treated for arthritis, neuritis, fibrositis, fasciitis, bursitis, migraine or pseudo-angina. Treatment has been directed to some localized area when it should have been directed to the source of the trouble—the cervical spine

The fifth group consists of those patients who have acute exacerbations of chronic symptoms Usually the present symptoms appear following sudden hyperextension of the

neck, which may occur in the course of their usual activities, or from some unusual but apparently trivial movement of the neck Stooping lifting holding the head in one position for long periods of time, reaching backward or above the head, throwing something trying to prevent a fall or any unguarded movement of the neck may have caused the acute attack of pain and disability

EXAMINATION

On examination it may be difficult to determine which nerve root or roots are actually irritated in as much as the segmental distribution of the cervical nerves is not confined strictly to the corresponding embryologic segment.

In many instances at least one fiber of a nerve root fails to continue in that particular nerve root but descends to join the adjacent distal nerve root For instance, one of the fourth nerve root fibers which leaves the cord at that level may actually leave the spinal canal with the fibers of the fifth nerve root (Figure 17) If this fourth nerve root fiber is irritated within the foramen of the fifth nerve root, findings indicating involvement of the fourth nerve root may be present.

There is an overlap of the peripheral sensory distribution, also so that no one area of skin is supplied by any one nerve root. Reflex stimulation of the sympathetic supply adds further confusion in the exact location of the site of involvement.

Electromyographic studies may be of some value in localization of the site of irritation However these studies are not diagnostic of the specific lesion which is responsible for the nerve root irritation

In many instances more than one nerve root is irritated If surgery is contemplated it is important to localize the site or sites of irritation but for conservative treatment the exact designation of a specifically irritated nerve root is not essential.

It is the author's belief that the fifth nerve root is irritated most frequently and that the sixth fourth, third, second, and seventh roots are irritated in that order of frequency Figure 44 illustrates the so-called segmental distribution

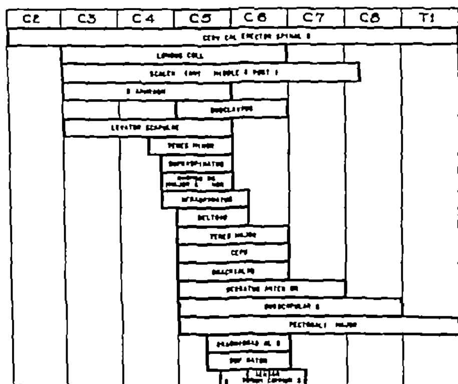


Figure 44 The segmental distribution of the fifth nerve root

of the fifth nerve root and shows that all the areas supplied by this nerve root receive innervation from at least one other nerve root

It must be remembered that irritation or compression of a nerve root may cause pain and/or sensory changes anywhere along its distribution Localized areas of tenderness and muscle spasm will be found at the site of the painful areas Not infrequently some areas of segmental tenderness are found of which the patient may not be cognizant These myalgic areas are found by deep palpation, in as much as hyperalgesia or superficial tenderness is not present

The examination form used by the author affords a simple outline of the pertinent points in the examination (Figure 45) The patient s general posture is of importance and should be noted The position in which the patient

EXAMINATION Posture ______
LIMITATION OF MOTION ______
NECK Lat. Bend. ______ Flexion ______
Rotation ______ Extension ______
SHOULDER JOINT ______
Abduction ______ Int. Rotation ______ Ext. Rotation ______
ELBOW ______
FINGERS ______
OTHERS ______
[illegible] AREAS ______
Head ______ Sternomastoid ______ L Rhb ______ Ins. Delt ______
Neck ______ Scalenes ______ Tail of Trap ______ Ext. Forearm ______
Suprascapular ______ U Rhb ______ Tip Sho ______ Chest ______
Other ______
COMPRESSION SIGN ______
WEAKNESS OF MUSCLES ______
REFLEXES ______
Biceps ______ Triceps ______ Br. Rad. ______
SENSORY CHANGES ______
Axillary Nerve ______ Ext. Sur. F. Arm ______
Lat. Sur. Arm ______ Fingers ______
Other ______
BLOOD PRESSURE ______
PUPILS ______
HEART ______
OTHER ______

Figure 45 Examination form used by the author

carries the head and neck is of great importance In acute unilateral subluxations the position of the head and neck is characteristic and, as stated, usually a diagnosis can be made as the patient enters the office The neck is usually held in slight flexion with the head tilted away from and the chin turned toward the side of involvement Lateral bending to the involved side and rotation to the opposite side are impossible Flexion and hyperextension may be limited

Some cases may show only a minimum amount of limitation of motion of the neck whereas others may show marked limitation in any or all directions Figure 46 illustrates the range of motion which occurs normally Any limitation in this excursion of movement should be considered abnormal.

Motion in the shoulder joints should be tested. It may vary from normal to a completely frozen shoulder Thirty-

five per cent will have some limitation of glenohumeral motion This may be due to voluntary immobilization because of pain or to reflex sympathetic dystrophy which gives rise to inflammatory and degenerative changes and to

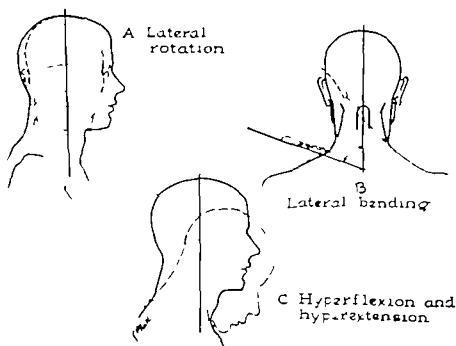


FIGURE 46 The normal range of neck motion The head can be rotated laterally so that the chin is parallel with the shoulder (A) It can be bent laterally seventy to eighty degrees (B) It can be flexed forward so that the chin touches the sternal notch and it can be bent backward so that the base of the skull touches the spinous process of C7 or T1 (C)

adhesive capsulitis and tendinitis as stated above Calcareous deposits in the cuff tendons occur in eight per cent of the cases, and give rise to varying degrees of limitation of shoulder motion

Motion in the elbow is not usually limited unless there is an epicondylitis or pain at the insertion of the biceps. Occasionally there may be limitation of finger motion which is usually due to swelling resulting from reflex irritation of the cervical sympathetics, or to fibrotic changes

in the palmar fascia because of reflex dystrophy Oppenheimer has described the "atrophic swollen hand" and believes these changes are due to irritation of the third or fourth nerve roots themselves and does not mention the possibility of sympathetic involvement [23]

Patients who complain of headache usually have painful areas at the base of the skull, over the mastoid area or over the temporal region Most of the patients will have painful areas in the posterior muscles of the neck on one or both sides and deep palpation may reproduce the radicular pain However in some instances there may be no actual tenderness of the neck muscles

Tenderness may be found over any of the spinous processes, and over any of the posterior joints. These joints may seem to be swollen or enlarged to the palpating fingers of the examiner

Almost all the patients have tenderness in the suprascapular muscles. These muscles include the trapezius supraspinatus and levator scapulae

Many of the patients who are seen immediately after a whip-lash injury have tenderness and muscle spasm of one or both sternomastoid muscles. Tenderness of the scalene muscles is usually present and can be found by the Judavich maneuver Tenderness in the upper rhomboid area, especially at the superomedial angle of the scapula, is the most constant finding Tenderness in the lower rhomboid area and at the tail of the trapezius muscle is found in some cases.

Tenderness at the tip of the shoulder is a frequent finding especially in patients who complain of limitation of motion of the shoulder joint Patients who have calcareous deposits within a tendon of the shoulder cuff have exquisite tenderness at the site of the deposit

If the patient complains of pain in the arm it is most frequently found at the insertion of the deltoid muscle Tenderness in the extensor muscles of the forearm may be

found in about five per cent of the cases If an epicondylitis is present tenderness is found over the lateral or medial epicondyle.

Tenderness to deep palpation may be found in the anterior or lateral areas of the chest Usually this tenderness is unilateral It is not unusual to find tenderness over the spinous process of C7 and/or D1 Other areas of tenderness may be present and should be noted The usual sites of tenderness are shown in Figure 47

Pressure applied to the top of the head when the head is tilted to the side of involvement may reproduce the radicular pain However, this maneuver may cause pain on the opposite side Pressure applied to the top of the head when the neck is in hyperextension almost always reproduces the

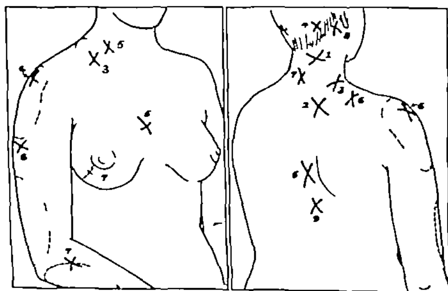


FIGURE 47 Sites of deep tenderness (X marks) and sensory changes (shaded areas) Numerals indicate order of frequency of myalgic areas.

pain The author calls this a positive hyperextension compression test and believes its significance is of diagnostic importance In some cases similar pressure applied with the neck in flexion reproduces or aggravates the pain

The shoulder depression test, as devised by the author,

gives information concerning the presence or absence of adhesions between the nerve roots and the capsular structures within the intervertebral canals (Figure 48). Downward pressure upon the shoulder with the head tilted to the opposite side places a pull or tug upon the nerve roots. This aggravates the radicular pain if the nerve roots are adherent to the canals.



FIGURE 48. The shoulder depression test. If this maneuver causes a reproduction or aggravation of radicular pain, it indicates adhesions about the dural sleeves of the nerve roots and the adjacent capsular structures.

The muscles of the arms and hands should be tested for weakness. Usually if there is muscular weakness it occurs in the extensor muscles of the arm and forearm Weakness of grip is due to weakness of or pain in, the extensor muscles of the forearm, or to a lateral epicondylitis. Some cases may show actual atrophy of the arm and forearm muscles.

The reflexes in the upper extremeties may be normal However the biceps reflex is frequently weak or entirely absent. Not infrequently the biceps reflex on the side opposite the involvement is absent The triceps reflex may be absent in a very small percentage of cases. The brachioradialis reflex is altered occasionally

Sensory changes may occur over the cutaneous distribution of the axillary nerve over the lateral surface of the arm, and over the extensor surface of the forearm (Figure 47) Occasionally there is definite hypesthesia of one or more fingers. The thumb index and long fingers show sensory changes more frequently than do the ring and little fingers

The blood pressure should be checked It has been interesting to note that patients who complain of shoulder and arm pain show a definite difference in the blood pressure reading of each arm. Usually the blood pressure is from ten to twenty points higher on the side of involvement than in the other arm.

In about five per cent of the cases dilatation of the pupil occurs on the side of involvement. This is due to the reflex stimulation of the cervical sympathetics, and is the opposite of Horner s syndrome in which there is constriction of the pupil due to paralysis or interruption of the sympathetics.[31] Dilatation of a pupil is found frequently immediately following a whiplash injury

The heart and lungs, of course, should be checked unless the patient has had a very recent physical examination

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The heart and lungs, of course, should be checked unless the patient has had a very recent physical examination

which showed no pathology in these organs. Any other findings which appear to be abnormal should be noted

In summarizing the clinical findings one can say that they vary with the nerve root or roots involved, but that the radicular pain and tenderness and the sensory changes follow fairly definite patterns corresponding to the distribution of the nerve roots Involvement of more than one nerve root is the rule rather than the exception.

X RAY FINDINGS

Adequate radiographic studies should be made in all cases of neck injuries, and in all cases in which there is a possibility of a mechanical derangement or other pathology causing irritation or compression of the cervical nerve roots. Correct interpretation of such studies is possible only when the interpreter has the opportunity to correlate the symptoms and the clinical finding with the x ray findings Much too frequently the radiographs are read as being "essentially negative," or as having no significant changes. It should be stressed and restressed that minimal changes may give rise to severe symptoms, whereas marked changes may give rise to minimal symptoms and clinical findings. Multiple views may be necessary to show what may appear to be an insignificant finding On the other hand one simple lateral view may demonstrate some gross pathological condition.

Lateral Views

The three upright lateral views as suggested by Davis should be made routinely (Figure 49)

The straight lateral view in seventy-eight per cent of all cases of cervical nerve root irritation will show a loss of the normal forward curve of the cervical spine This is due to spasm or contraction of the prevertebral and lateral vertebral muscles — longus capitus and colli, recti and the scalene. A reversal of the curve, which is usually localized to three or four segments, will be found in approxi-



FIGURE 49A The Davis series of x-ray films. Straight lateral view Note loss of forward curve and narrowing of disc between C5 and 6.



FIGURE 49B Flexion view



FIGURE 49C. Hyperextension view. Note posterior subluxation of C3 on 4, C4 on 5 and C5 on 6.

mately twenty per cent of these cases. The apex of the reversed curve indicates the site of maximum irritation, usually. The reversed curve may be high in the cervical spine. This is true especially in children (Figure 50).



FIGURE 50. A lateral radiograph of the neck of a child, age three, who had had a sprain injury of the cervical spine. Note the reversal of the curve at level of the second and third vertebrae. This is a frequent finding in sprain injuries of the neck in children.

In some instances the reversed curve may present a sharp angulation at one specific level (Figure 51A and 51B) Such angulation may be caused by a tearing of the interspinous ligaments or by rupture and extrusion anteriorly of the intervertebral disc [19] Forward subluxation of the posterior articulations with widening of the joint spaces and separation of the contiguous spinous processes may be responsible for the sharp angulation posteriorly

It has been stated that a loss of the normal lordotic curve, or a straightening of the cervical spine, may be the result of some emotional factor [24] and that therefore it has little significance from the standpoint of diagnosis. However, once the emotional disturbance has been corrected, the lateral radiograph should show a restoration of the normal forward curve of the cervical spine

Steindler has referred to the loss of the normal lordotic curve as the 'antalgic position' [28] It is in this position that the patient experiences some relief of his pain If this position persists, eventually hyperextension, which normally increases the lordotic curve, may be impossible.

The forward flexion view demonstrates the location and amount of forward flexion Not infrequently the neck may appear on examination to have a normal range of motion, but the x ray film may reveal that motion occurs between the atlanto-occipital and atlanto-axial articulations and between the cervicothoracic joints with little or no motion occuring in the other cervical joints. In other instances there may be no demonstrable motion between the first and second vertebrae or none between any two other vertebrae (Figure 52)

Anterior subluxation or actual forward slipping of one vertebra upon its adjacent distal vertebra may be seen in the forward flexion view One or more forward subluxations may be present The gliding motion which occurs between the vertebrae, which has been demonstrated by cineradiography* when flexion of the neck takes place in a

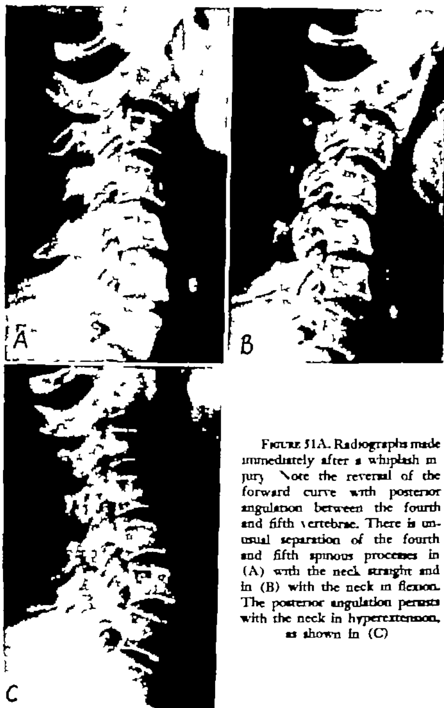


FIGURE 51A. Radiographs made immediately after a whiplash injury. Note the reversal of the forward curve with posterior angulation between the fourth and fifth vertebrae. There is unusual separation of the fourth and fifth spinous processes in (A) with the neck straight and in (B) with the neck in flexion. The posterior angulation persists with the neck in hyperextension, as shown in (C).

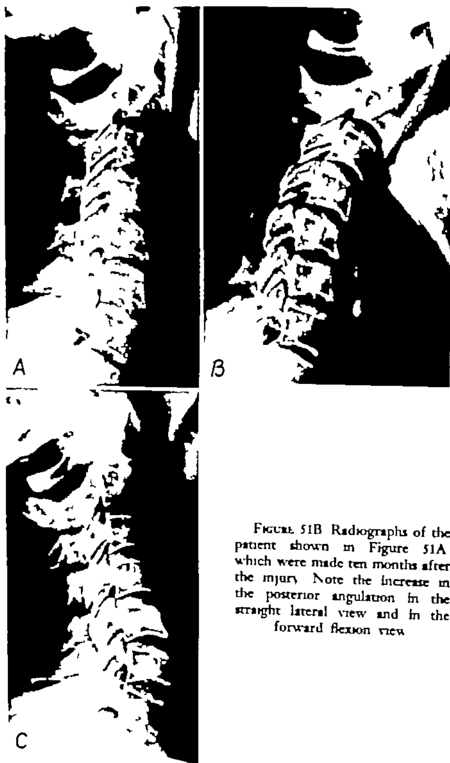


FIGURE 51B Radiographs of the patient shown in Figure 51A which were made ten months after the injury. Note the increase in the posterior angulation in the straight lateral view and in the forward flexion view.

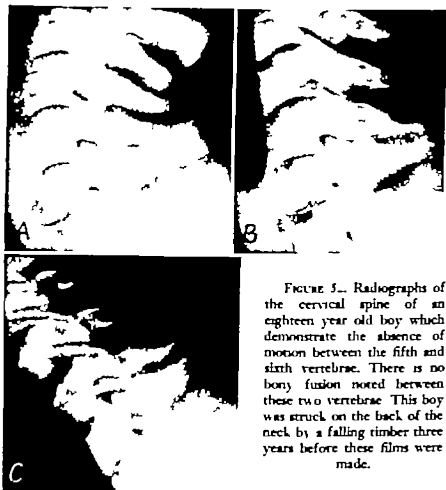


Figure 5[illegible]. Radiographs of the cervical spine of an eighteen year old boy which demonstrate the absence of motion between the fifth and sixth vertebrae. There is no bony fusion noted between these two vertebrae. This boy was struck on the back of the neck by a falling timber three years before these films were made.

subject which is considered to be normal does not represent a true subluxation due to ligamentous instability. A radiographically demonstrable forward subluxation of one vertebra upon another should be indicative of ligamentous or skeletal instability even in the absence of a known injury.

The hyperextension view demonstrates the range and location of backward motion and the presence or absence of posterior subluxations. Posterior subluxations do not occur in the absence of ligamentous instability (Figures 53A and 53B).

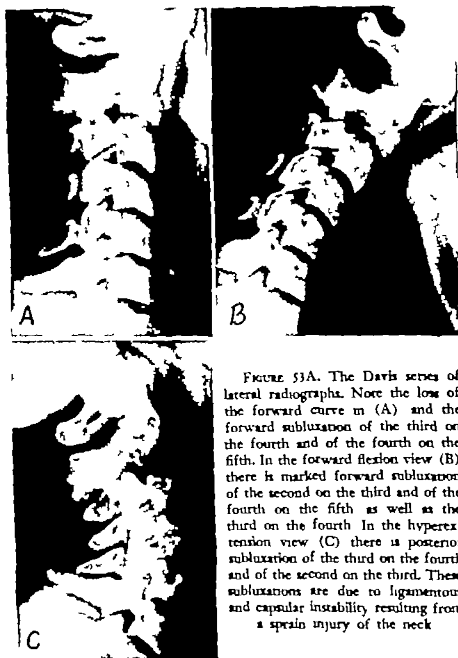


FIGURE 53A. The Davis series of lateral radiographs. Note the loss of the forward curve in (A) and the forward subluxation of the third on the fourth and of the fourth on the fifth. In the forward flexion view (B) there is marked forward subluxation of the second on the third and of the fourth on the fifth as well as the third on the fourth. In the hyperextension view (C) there is posterior subluxation of the third on the fourth and of the second on the third. These subluxations are due to ligamentous and capsular instability resulting from a sprain injury of the neck

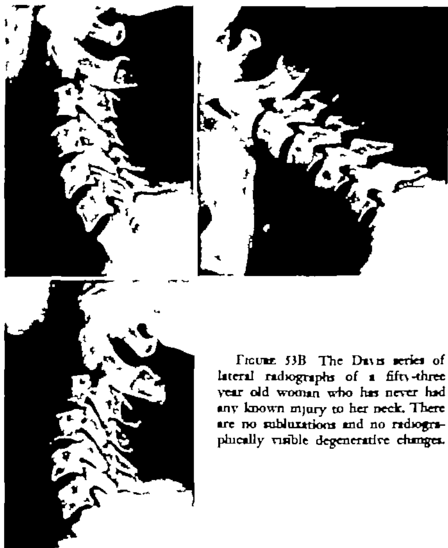


FIGURE 53B The Davis series of lateral radiographs of a fifty-three year old woman who has never had any known injury to her neck. There are no subluxations and no radiographically visible degenerative changes.



FIGURE 54 Fracture of the body of the fourth vertebra and forward luxation of the second on the third, caused by tearing of the posterior ligamentous and capsular structures at this level, can be seen in (A) Reduction accomplished by skeletal traction is shown in (B)



FIGURE 55 A compression fracture of the anterosuperior portion of the seventh cervical vertebra was not noted in the initial post-injury film (A) but it was definitely evident in the film made two months later as shown in (B)



FIGURE 55C. Compression fracture of the body of C7 which was not discovered until two months post injury. The shoulders prevented adequate visualization of the seventh vertebral body.

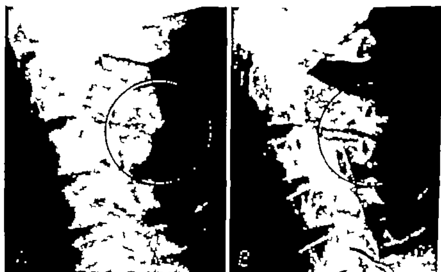


FIGURE 56. A fracture of the lamina of the second vertebra with forward luxation of this vertebra, and a fracture of the spinous process of the third vertebra can be seen in (A). There is an avulsion of the spinous process of the fourth vertebra, also. In (B) the fractures are healed.

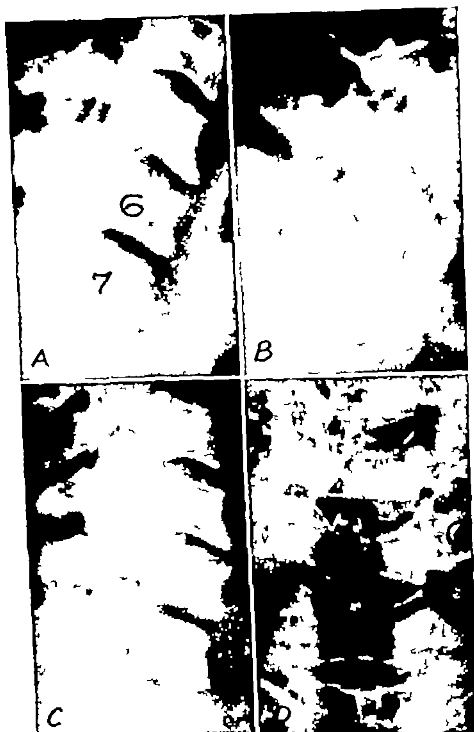


FIGURE 57 Persistent anterior subluxation in all lateral views, and widening of the lateral intervertebral joint space on the right side in the anteroposterior view



Figure 58 Left (A) and right (B) oblique flexion views to show cause for persistent subluxations of C6 on 7 in Figure 57
Note fracture of vertebral arch of C6 in (A)

All lateral views may show the presence of compression fractures of the vertebral bodies at any level (Figures 54) Compression fractures may not be evident on the initial radiograph, but may be definitely visible on subsequent films (Figure 55)

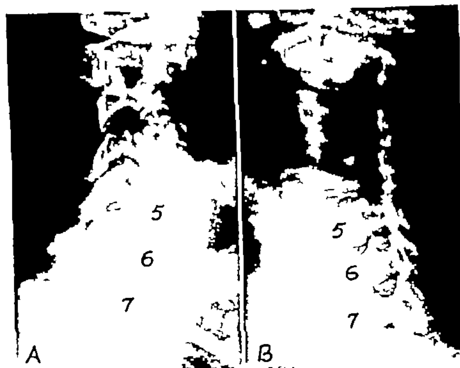


FIGURE 59 Fracture of the inferior facet of C6 on the left side Note changes in intervertebral canals between C5 and 6 and between C6 and 7 and the forward subluxation of C6 and C7 on the left side only

Fractures of the spinous processes and of the laminae can be noted on the lateral views (Figure 56)

All lateral views may show a persistent forward subluxation, in which event one should look for a fracture through the vertebral arch or through the inferior facet of the forwardly displaced vertebra (Figures 57 58 & 59) These fractures are best demonstrated by flexion-oblique views and by lateral-oblique views which throw the articular facets into the correct position for proper visualization.

Approximately forty-six per cent of the cases examined will show narrowing of one or more intervertebral discs. Hypertrophic changes of varying degrees may be noted in the films which show narrowed discs. These changes of

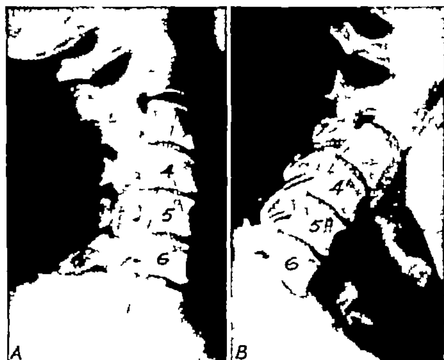


FIGURE 60 Fixation of vertebrae adjacent to narrowed discs. (A) Hyperextension view (B) Flexion view (Straight lateral view same as A.)

the vertebrae adjacent to the narrowed discs lead to fixation of these vertebrae and such fixation can be noted in the three lateral views (Figure 60) Hypertrophic conditions occur most frequently between the fifth and sixth and between the fourth and fifth vertebrae or in the areas which are most subject to stress and strain and to trauma. However they may occur at any level (Figure 23) Subluxations may occur above or below the fixed areas as a result of recent sprain or from undue relaxation of the ligamentous and capsular structures of the adjacent vertebrae. One or more subluxations will be present in ninety-five per

cent of all cases. It has been noted that the most frequent subluxation occurs between C4 and C5 Some radiologists consider this subluxation to be normal and do not report it in their findings. However, it is my belief that it should be considered abnormal in as much as the fifth nerve root is the one most frequently irritated or compressed It must be remembered however, as stated above, that the extent of the mechanical derangement is no indication of the amount of irritation of the nerve root. In some cases there may be clinical evidence of severe nerve root compression without demonstrable mechanical alterations

Oblique Views

Oblique views give information concerning the intervertebral foramina. Spur formations at the margins of the lateral intervertebral joints may be seen projecting into the intervertebral foramina causing anteroposterior narrowing (Figure 61) However it must be kept in mind that the

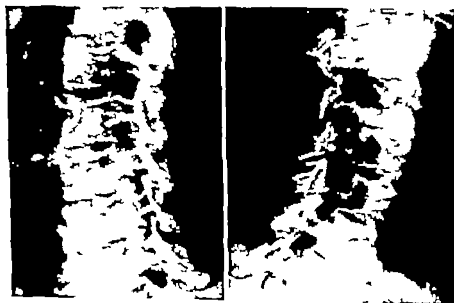


Figure 61 Oblique views which illustrate narrowed intervertebral canals due to spur formations at the margins of the lateral interbody joints. These changes occur over a period of years, but such joints and the adjacent nerve roots are much more susceptible to injury than are normal structures.

exact amount or extent of the spur formations cannot be determined in the x ray films. In anatomical specimens the author has found that the greatest amount of hypertrophic



FIGURE 62 Hypertrophic changes – lateral and semi-oblique views. Note appearance of spur formation at posterior portion of C4 5 and 6 in (A) Note marked spur formation about the margins of the lateral intervertebral joints at C4 5 and 6 in (B) Spur formations do not occur at the posterior margins of the vertebral bodies, although the lateral film gives that appearance.

spur formation occurs at the margins of the lateral intervertebral joints. In the lateral x-ray films these may appear to be projections on the posterior surface of the margins of



FIGURE 63 Lateral-oblique views, which show the posterior articulations. The patient shown in (A) has had a partial facetectomy at C5 and 6. The short arrow points to a fragment of bone which was not removed This patient's symptoms were not relieved by the operation. The radiographs (C) and (D) are those of a patient who had received a neck injury in childhood. There is bony fusion between the posterior portions of the bodies of C5 and 6, and an avulsion of the spinous process of C5 as shown in (D) The lateral oblique (C) shows that there is no bony fusion of the facets.

the vertebral bodies These changes may be demonstrated best in semi-oblique views as shown in Figure 62(B)

Oblique views made with the neck in flexion reveal fractures of the articular processes and of the vertebral arches These views should be made in all cases which show persistent forward subluxations in the three lateral films. A unilateral fracture of a vertebral arch or of a posterior facet, permits forward subluxation of the vertebral body on that side and no subluxation can be seen on the other side (Figures 58 and 59)

Lateral oblique views show the posterior articulations from a different angle (Figure 63) and may be of diagnostic aid in injuries of the facets Spur formations about the margins of the facets can be demonstrated in this projection

Anteroposterior Views

Anteroposterior films made with the tube tilted upwards twenty-five to thirty-five degrees so that the central rays pass through the intervertebral spaces will demonstrate the upward projections at the sides of the superior surfaces of the bodies of the vertebrae Narrowing or widening of the lateral intervertebral joint spaces as well as spur formations about the joints can be seen (Figure 64)

The anteroposterior view is of tremendous value as a diagnostic aid and it should be made routinely This view when made correctly gives more information concerning the lateral interbody joints than any other view The extent of hypertrophic changes about these joints and their encroachment upon the intervertebral canals can be seen (Figure 65)

A compression fracture of an upward lateral projection of a vertebral body may be found in this view (Figure 66) A side lashing neck injury can cause such a compression.

Widening of a lateral interbody joint space on one side may be caused by hemorrhage into the joint, it may indicate

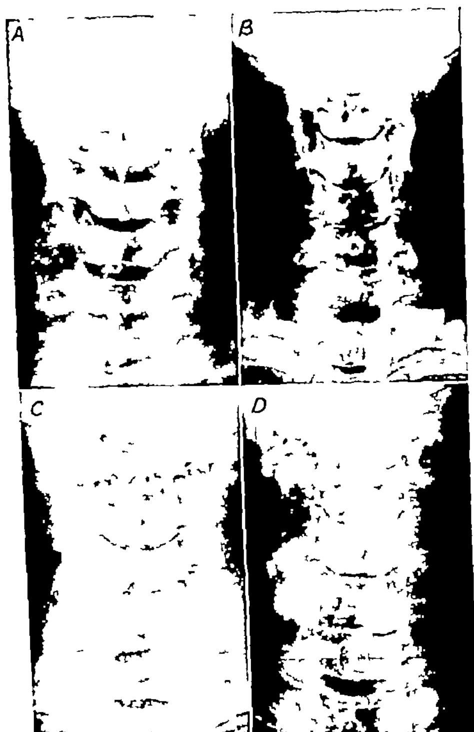


FIGURE 64 Anteroposterior views of cervical spines. Relatively normal appearing disc spaces and lateral intervertebral joints can be seen in (A) Note marked degenerative and hypertrophic changes in (B) (C) and (D)

a unilateral subluxation of the adjacent posterior joint or it may indicate a fracture of a vertebral arch or of a facet at that level (Figure 57(D)) When there is separation or



FIGURE 65 An anteroposterior view of a cervical spine which has been enlarged to show more distinctly the marked hypertrophic changes about the lateral interbody joints. Note that the joint between the sixth and seventh vertebrae on the left side has escaped these marked changes.

widening of an interbody joint space on one side there is a corresponding narrowing on the opposite side usually

Narrowing of both lateral interbody joints is present

FIGURE 66. Compression fractures of the upward lateral projections of the body of the fourth vertebra, resulting from a side lashing injury

when there is degeneration and narrowing of the adjacent disc space

A decrease in the vertical diameter of a vertebral body which has suffered a compression fracture can often be demonstrated in the anteroposterior view

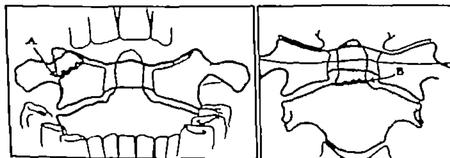


FIGURE 67 Sketch of x-ray films of C1 and 2 showing fracture of a superior articular facet of C1 in (A) and fracture of the odontoid process of C2 in (B)

Radiographs of the atlas and axis should be made of all patients who have had a recent neck injury and in all cases with symptoms of occipital headaches and of "black outs" Fractures of the odontoid process and of the lateral articular processes can be demonstrated in these films usually (Figure 67) Changes in the relationship of the lateral masses of the atlas and the odontoid process may be noted which in the absence of a congenital anomaly, is indicative of injury to the retaining ligaments of the atlas (Figure 68)



FIGURE 68 A radiograph of the first two cervical vertebrae which demonstrates a marked subluxation of the atlas on the axis to the right side.

Myelographs

Myelographic studies may be indicated if the clinical findings are suggestive of a space-occupying lesion or if conservative treatment gives no relief Proper interpreta

tion of these studies is of the utmost importance in as much as a defect in the column of radio-opaque material does not signify a space-occupying lesion necessarily Of interest in this connection is the work done by Kaplan and Kennedy on the effect of head posture on the manometrics of the cerebral spinal fluid in cervical lesions They found that flexion and hyperextension of the neck altered the manometric readings in twelve of thirty-one patients who had had a clinical diagnosis of cord compressing lesions.[17] Exploratory laminectomy was done on eight cases. Seven of these had shown a complete block with the neck in hyperextension and one had shown a partial block No tumors were found. Compressing exostoses were found in four at C5 and 6 Permeated discs were reported in two and adhesive arachnoiditis accounted for the changes in the other two cases The spinal fluid protein levels varied from normal to slight elevation Myelographs were done in four of the twelve cases, and each showed a complete stoppage of the pantopaque with the necks in hyperextension As the necks were slowly flexed the pantopaque dribbled along the lateral sides of the defects. Myelography confirmed their findings on the effect of head posture on blockage of the cervical sub-arachnoid space

Figures 69 (A) and (B) show the myelographs of a patient which were reported as demonstrating a ruptured disc at the C5 and C6 level bilaterally However the defects are directly over the lateral intervertebral joints, and may be caused by swelling capsular thickening or marginal hypertrophic spurs of the joints rather than by protruding disc material The patient s chief symptoms were headache and pain in the neck Conservative treatment consisting of intermittent traction collar immobilization and procaine injections gave adequate relief Another patient who had similar myelographic films (Figures 69 (C) and (D)), was operated on for a ruptured disc The symptoms were bilateral The removal of disc material and pieces of bone

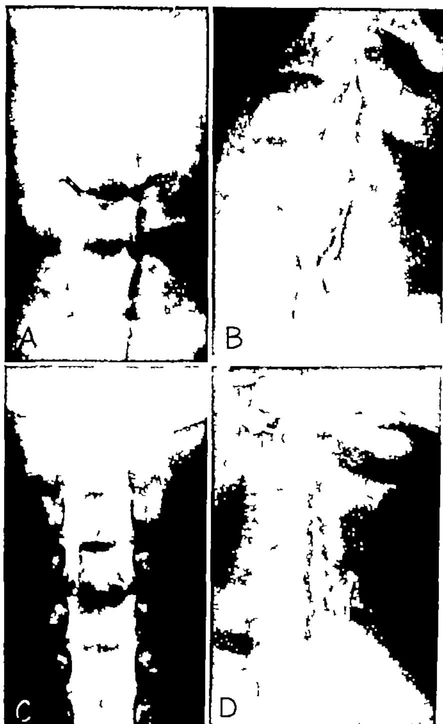


FIGURE 69 Myelographs of two patients reported as demonstrating a ruptured disc" at C5 and 6 level bilaterally

from one side was reported In all probability marginal spurs on the lateral intervertebral joint and thickened capsular material were removed

Myelography is indicated only when adequate conservative treatment fails or if there is some indication of actual cord involvement or a space occupying lesion One should hesitate to inject a radio-opaque material into the cervical spinal canal unless it is absolutely necessary Too frequently we find that this material has been allowed to flow into the recesses of the brain where it has remained Supposedly it causes no ill effects, but we cannot say positively that it does not

Shoulder Films

If a patient complains of pain in the shoulder joint and limitation of glenohumeral motion anteroposterior and lateral films of the upper end of the humerus should be made. As stated above, eight per cent of the patients who have mechanical derangements of the cervical spine with cervical nerve root irritation show calcareous deposits in the musculotendinous cuff (Figure 70 (A) and (B)) A single view may not demonstrate the calcareous deposit. Therefore, two views should be made routinely in all cases complaining of shoulder pain and limitation of glenohumeral motion whether of short or long duration

A large deposit of calcareous material may be found in the musculotendinous cuff of a patient who has had pain and limitation of motion for only a few hours.

Films of a "frozen shoulder" that is one with advanced adhesive capsulitis or tendinitis, may show actual narrowing of the glenohumeral joint space There may be x ray evidence of degenerative changes within the head of the humerus



FIGURE 70A Film of a shoulder showing a calcareous deposit.



FIGURE 70B Film of the cervical spine of patient in 70A, showing a narrowed disc at C5 and 6.

Chapter 6

DIFFERENTIAL DIAGNOSIS

PAIN caused by irritation of cervical nerve roots or trunks must be differentiated from the following conditions 1 Pain reflexly referred from somatic and visceral structures. 2 Pain resulting from irritation of a nerve or branch of a nerve 3 Pain caused by some lesion within or about the spinal cord 4 Pain resulting from lesions of the brain. 5 Pain of psychogenic or psychosomatic origin

Such differentiation is not too difficult if one keeps in mind certain neurological considerations 1 Pain from irritation of a nerve root or a nerve trunk is referred to points along the segmental distribution of that nerve root or trunk distal to the source of the irritation. Such areas of referred pain are accompanied by deep tenderness and muscle spasm [14, 9] 2 If a nerve itself or a branch of a nerve is irritated pain may be referred to the periphery either proximal or distal to the site at which it occurs but the painful areas are not tender to deep palpation [1] 3 Pain which originates in a somatic or visceral structure may be reflexly referred along the segmental distribution of the nerve or contiguous nerves which supply that structure, but these areas of referred pain are not tender on deep palpation. There may be superficial tenderness or hyperalgesia which may represent reflex sympathetic irritation with a resulting peripheral expression due to vasomotor changes. It may be due to irritation of the afferent pain conducting fibers which accompany the sympathetic fibers. 4 Sensory motor and trophic changes do not involve the region of reflexly referred pain The reflexes should be

normal However, reflexly referred pain and cervical nerve root irritation may occur at the same time, in which instance differentiation is often difficult 5 Pain which results from lesions of the cervical spinal cord and of the brain follows no definite nerve root pattern and is ill-defined and indistinctly demarcated The lower extremities may be involved as well as the upper extremities Coughing sneezing and straining increase or aggravate the pain, usually Spasticity or hypertonia and hyperactive reflexes are the rule whereas lesions effecting the nerve roots cause hypotonia and decreased reflexes.

If there is doubt in the differential diagnosis the simple procaine injection test will, if done properly dispel that doubt usually Injection of a local anesthetic into a myalgic area resulting from cervical nerve root irritation will reproduce momentarily the radicular pain and then give dramatic relief of pain for days weeks or months A local anesthetic injected into a painful area where there is no associated deep tenderness will give fleeting relief of pain in that area and there will be no reproduction of radicular pain at the time of the injection Behan called attention to this fact forty years ago [1]

The following conditions which may give rise to symptoms that might be confused with cervical nerve root irritation must be considered 1 Malignancies, tumors, infections, inflammation and trauma involving somatic or visceral structures which have the same segmental innervation 2 Tumors, diseases and injuries of the cervical vertebrae which may produce space-occupying lesions within the spinal canal 3 Tumors, diseases and trauma of the spinal cord itself 4 Tumors and diseases of the brain. 5 Basilar impression, which is a congenital malformation of the craniovertebral boundary with encroachment of bone on the adjacent neural structures. 6 Lesions of specific nerves or their branches.

A few case histories may help to clarify some of the differential diagnostic points

Case Number One White male, age 67 had had excruciating pain in the right shoulder and arm of several months duration. He had a marked kyphosis and scoliosis of the upper dorsal vertebrae with marked compensatory hyperextension of the neck and narrowing of the right intervertebral foramen between C4 and 5 — an excellent candidate for cervical nerve root irritation. Treatment was directed toward the cervical spine without proper differential diagnosis. Procaine injections gave only temporary relief Traction gave no appreciable relief It was then necessary to look for a lesion of a viscera with the same segmental nerve supply X ray films of the chest revealed a bronchogenic carcinoma

Case Number Two White male, age 65 complained of pain in the left arm which had been present since a fall on the elbow three months previously He consulted his family physician who made a diagnosis of "muscular soreness." The pain became worse and he consulted a surgeon who sent him to the author

His presenting symptoms were Pain in the left elbow and shoulder Pain behind the shoulder and in the left chest anteriorly Examination revealed evidence of an old abrasion over the tip of the elbow There was a full range of elbow and shoulder motion All neck motion was markedly limited There was marked deep tenderness in the posterior neck muscles on the left side and in the upper rhomboid area Tenderness over the left sixth rib anteriorly was present The compression sign was positive on the left side. The reflexes were normal and there were no sensory changes.

X ray films of the shoulder and elbow were negative. A single lateral view of the cervical spine revealed narrowing of the intervertebral disc between C6 and 7 and calcification of the anterior longitudinal ligament at this level.

There was some irregularity of the posterior articulations of C6 and 7 An anteroposterior view showed definite

spur formation at the margins of the lateral intervertebral joints between C5 and 6 and C6 and 7

A diagnosis of cervical nerve root irritation, resulting from the thrusting force of the body weight on the elbow at the time of the fall, was made.

Monocaine was injected into the tender rhomboid area This gave him complete relief of pain in his shoulder and arm. However the pain in his chest persisted and was always aggravated by hyperextension of the neck.

Two weeks later it was noted that this patient had some difficulty in breathing An x ray film of his chest revealed an inoperable bronchogenic carcinoma of the left lung with pleural effusion and pathologic fractures of the fifth and sixth ribs in the anterior axillary line.

This man had pain due to cervical nerve root irritation as well as localized pain at the site of the pathologic fractures.

Case Number Three White male, age 31 had had pain in his neck, shoulders, arms and hands with numbness and tingling of the third and fourth fingers of both hands for four weeks. He had had two injuries to his neck ten and fifteen years previously He had had one attack of neck, shoulder and arm pain several months previously which had responded to bed rest and traction. His presenting symptoms had come on suddenly as he was going down some steps. They had grown increasingly more severe and were worse at night so that three or four hypos were necessary for him to get any rest Coughing sneezing and straining at stool caused aggravation of his pain. He had been hospitalized for cervical traction and had then been fitted with a cervical brace without relief

Examination revealed that there was marked limitation of all neck motion and that any attempt to move the neck caused severe pain. The posterior neck muscles were somewhat spastic but there were no localized areas of muscle spasm. The biceps reflexes were slightly hyperactive. All other reflexes were normal and there were no definite sensory changes. There was no muscular weakness or atrophy

X ray films revealed that there was very little motion in his cervical spine. There was an anterior subluxation of C3 on C4 and a posterior subluxation of C4 on C5

The severe symptoms and the minimal clinical findings were not indicative of cervical nerve root irritation per se. Procaine injections gave temporary relief

Myelographic studies revealed an almost complete block at the C4 and 5 level. The spinal fluid examination revealed a protein content of one hundred twenty-eight milligrams.

Neurological consultation was obtained but due to the absence of positive clinical findings surgery was not recommended at that time.

With further bed rest and traction he improved a great deal and was allowed to return to his home Two weeks later his pain became so severe that he was hospitalized in his home town and further neurological consultation was obtained there A laminectomy of C3 to C6 was done and it was found that there was a fusiform enlargement of the cervical cord at C4 and 5 The neurosurgeon stated that he believed this enlargement represented an intramedullary neoplasm but in as much as there were so few neurological findings he did not believe he was justified in opening the dura.

X radiation therapy was given following the decompression operation and he was allowed to return to work after about two months He was unable to continue his work, however and he was then given another series of x radiation therapy This man continued to have pain and numbness in his arms and hands. He developed some muscular weakness which was worse following his second series of x ray treatments. However within eight months he was able to return to work and presently five years later is having very little difficulty

Case Number Four A white male, age 65 complained of pain in his neck and pain in the mid-dorsal area which radiated around his chest wall and abdomen. Complete chest, liver gall bladder heart and spine studies had been

done six months previously Apparently nothing abnormal was found, and no treatment was given.

Examination revealed limitation of neck motion in flexion and in lateral bending and rotation. The patient's general posture was poor at that time in as much as he was beginning to slump with resulting marked hyperextension of his neck There was pain and superficial and ill defined tenderness over the spinous processes of the seventh, eighth, and ninth dorsal vertebrae This finding is significant in as much as it is characteristic of duodenal ulcer pain. Sir William Bennet made this observation in 1904 [8] There was no definite evidence of cervical nerve root irritation at that time.

The straight lateral x ray film revealed a marked increase in the forward curve of the cervical spine with some posterior subluxation of C4 on C5 The forward flexion view revealed definite anterior subluxation of C4 on C5 C5 on C6 and C6 on C7 The hyperextension view revealed posterior subluxation of C3 on C4 and of C4 on C5

This patient's pain was not localized but was diffuse over the mid-dorsal area, posterior chest wall and upper abdomen.

A monocaine injection at the level of the seventh, eighth and ninth dorsal vertebrae gave him temporary relief only as was anticipated. In as much as this patient had had a previous duodenal ulcer had been on a strict diet and had taken Banthine he was advised to return to his diet and to the Banthine. At the end of two weeks the pain in his mid-dorsal area, chest and abdomen had disappeared but he was still complaining of some pain in his neck. He was fitted with a shoulder brace to improve his posture. Wearing the brace gave him some relief of his pain He was advised to get away from the pressure of his business for a vacation. He returned six weeks later at which time he was completely free of pain

He was not seen again for another six weeks. At that time he returned complaining of pain in his left arm at the insertion of the deltoid and of pain in both wrists. The

pain was always worse at night He was given intermittent cervical traction. He continued to improve over a period of three weeks. He then had severe neck, shoulder and arm pain on the left side which required a narcotic for relief

On examination it was noted that pressure on the left side of the neck at C5 and 6 caused a reproduction of his pain in his shoulder arm and hand. A monocaine injection into the posterior muscles of the neck on the left side gave complete relief of pain. However there was something about the clinical picture which was suggestive of other pathology He was sent to a cardiologist who found that this man had had a mild cardiac infarction which was believed to have occurred six or eight months previously Mild congestive heart failure was present and the patient was hospitalized for three weeks. Two weeks later he was rehospitalized and operated on for a perforated duodenal ulcer Five days later he died, apparently of cardiac failure.

This case well illustrates the importance of differential diagnosis. The patient did have evidence of irritation of the fifth and sixth cervical nerve roots but this condition was much less significant than his other lesions.

Case Number Five White male, age 34 was referred by an internist because of persistent and uncontrolled headaches of three years duration. His headache came on very suddenly as he stooped over to pick up something Several weeks after the onset he consulted his family physician who gave him some medication for the pain The pain was always aggravated by certain positions or movements of the head and could be relieved by tilting his head forward. The pain was located in the back of his neck and at the base of his skull with radiation behind his ears. Over a period of three years he saw an opthalmologist, otolaryngologist, an orthopaedist and a neurosurgeon. None of these found any cause for his headaches and he was sent then to a psychiatrist who sent him to a state institution for electro-shock therapy He received seven shock treatments and was then sent home with his headache and with new symptoms of "black-outs" and loss of balance. Later

his family doctor sent him to another neurologist with the suggestion that the patient might have a brain tumor The neurologist told him that "he was crazy and that he should be sent to an institution He returned to the hospital for further shock treatment which gave him no relief Later he consulted an internist who gave him histamine injections. These gave him some relief of his headaches. The internist referred him to the author because he thought there might be somthing wrong with his spine.

The presenting complaints were 1 Headaches at the back of head and neck which were worse whenever he attempted to lie down. It was necessary for him to sleep propped up with two or three pillows. 2 Loss of balance and inability to walk without assistance. 3 Difficulty in swallowing which was more pronounced in the late afternoon. 4 Stiffness of his neck. 5 Numbness and tingling of the fingers of the right hand especially the little and ring fingers.

This young man was a most pathetic individual. As he sat in the examining room it was noted that his posture was very poor He sat in a markedly "slumped" position with his neck in marked hyperextension His face was almost expressionless. He seemed afraid to move

Examination revealed marked limitation of all neck motion except in hyperextension. However hyperextension caused pain in his neck and at the back of his head There was definite tenderness on both sides of the neck posteriorly All his reflexes were hyperactive except the abdominals which were absent. There was definite hypesthesia along the cutaneous distribution of both axillary nerves and of the fourth and fifth fingers on the right hand When he stood up he could not walk for a few seconds because he had a sensation of blacking out" and of loss of balance As he walked with assistance it was noted that he walked with a wide base or with his feet some distance apart and with each step it looked as if he might fall.

X ray films of his cervical spine revealed changes which might account for some of his symptoms. It was obvious

that this patient needed treatment and encouragement. He was fitted with a shoulder brace in an effort to correct his poor posture. He was given intermittent traction and a felt collar was applied. After the sixth treatment he was greatly improved and his poor posture was corrected. Two weeks after his treatment was started he was able to go to his place of business for two hours each day. He then came in at weekly intervals for intermittent traction and for observation. He and his whole family were greatly encouraged.

At times he continued to complain of difficulty in swallowing and of occasional dizziness when he got up suddenly from a sitting position. Sneezing and coughing seemed to aggravate his pain at all times. His walking improved somewhat. However, in as much as his symptoms and clinical findings were suggestive of some other lesion he was hospitalized for myelographic studies, the only clinical test that had not been done. He had been told that he had two compression fractures in his lower back following the shock treatments. However, the x-ray films of his lower back and the myelographic studies were entirely negative for fracture and for any space-occupying lesion in the cervical spine.

He had a stormy time following the myelographic studies with more difficulty in swallowing and more dizziness. After a few days his symptoms subsided somewhat and he was able to return to his place of business for a few hours each day and was able to drive his car for short distances. He was last seen on December 10, 1953 at which time he was feeling much better and was in very good spirits. Three days later his wife called to report that he had a cold and that he was having some difficulty in swallowing. That night he slept very little and was unable to swallow or to take any fluids by mouth. Early the next morning he sneezed, became cyanotic and expired before medical aid could be obtained.

An autopsy was done which revealed the following conditions: 1. Acute suppurative bronchiolitis, bilateral, with spreading and rapidly developing bronchopneumonia and

with resulting generalized acute toxemia and acute myocardial degeneration. 2 Persistent lymphoid tissue state, possibly being responsible for generalized lowered resistance. The persistence of lymphoid tissue in an abnormal amount was found in the thymus, the thyroid the spleen and all lymph nodes. 3 Cyst of the cerebellar vermis extending into the sub-arachnoid space and separating the cerebellar hemispheres. The cyst was not recognizable as a specific histologic lesion. There was no evidence of inflammation or of neoplastic disease 4 Constriction of the esophagus immediately below the larynx. This constriction was apparently of congenital origin.

The following symptoms which this patient had could have been explained on the basis of cervical nerve root irritation headaches, difficulty in swallowing loss of balance, pain in the neck numbness and tingling of the fingers, and aggravation of symptoms by hyperextension of the neck. The persistent hyperactive reflexes and staggering gait could not be explained on the basis of irritation of the cervical nerve roots. The encouragement which this patient received rather than the treatment may have been responsible for his improvement until he developed a severe and overwhelming bronchopneumonia against which he lacked the usual resistive forces.

A differential diagnosis can be made usually if one remembers that irritation or compression of the cervical nerve roots with radiation of pain is accompanied by deep tenderness at the site of the painful areas There may be segmental areas of deep tenderness that are not painful until palpated, which is further evidence of nerve root involvement If there is doubt concerning the differential diagnosis the simple procaine or local anesthetic injection test will dispel that doubt in most instances Injection of a local anesthetic into myalgic areas which result from cervical nerve root irritation will reproduce momentarily the radicular pattern of pain and then give dramatic relief for days, weeks or months. Injection of a local anesthetic into a painful area where there is no associated tenderness will

give fleeting relief of pain in that area and there will be no reproduction of the radicular pain at the time of injection. One should then look elsewhere for the lesion or lesions responsible for the pain. Visceral or somatic structures which have the same segmental nerve supply will be the offenders in all probability

Chapter 7

TREATMENT

In as much as pain is the symptom which brings the patient to the doctor's office treatment must be designed for its relief, as well as for the restoration of function. Of necessity such treatment must be individualized because of the differences in pain tolerance and in the emotional and constitutional variations of each individual. The patient must be studied with consideration of these factors and not as just another patient with a pain in his neck. Patience, tolerance and understanding are necessary on the part of the physician. An attempt should be made to explain the situation to the patient in simple language and on the basis of a mechanical derangement. It should be explained that relief can be given but that remissions will occur from time to time. An effort should be made to teach the patient how to live with his neck and how to adjust his every day activities to the altered mechanics of his cervical spine.

The author cannot stress too frequently nor too loudly the importance of teaching each patient how he can protect his neck to avoid exacerbations of his symptoms. The physician, one skilled in the art of healing must be a teacher also and that in spite of the extra time factor involved. It is true that some patients resist teaching and some cannot learn, but at least the attempt should be made.

Attention should be given to the patient's general health and habits. Infections should be eliminated. Poor dietary habits should be corrected. Allergies and hormonal imbalances should be treated.

The prevention of injuries will of course eliminate the

necessity for treatment in a very large percentage of cases. Many colleagues, as well as patients, have inquired concerning the use of seat belts, or safety belts. The advantages and disadvantages of such appliances in motor vehicles in the prevention and/or causation of musculoskeletal and ligamentous injuries have inspired investigative and experimental work in this field much of which is well documented in Volume 9 of *Clinical Orthopaedics*." The author's own opinion is seat belts can only increase and intensify injuries of the neck." The weight of the average skull, which is six to seven pounds, balanced upon the slender and very flexible cervical spine makes it extremely vulnerable to injury on sudden forceful deceleration or acceleration of the body. If the body is restrained, the lashing effect upon the neck is greatly increased.

The importance of a knowledge of the injuries which occur to the spine, and more especially to the cervical portion of the spine must be stressed and restressed. There is a too great tendency particularly in the emergency rooms of most hospitals, toward inadequate examination and disposition of motor vehicle accident victims. If the victim can walk, or if he has no grossly obvious injuries he is often sent on his way with a bit of advice to take some aspirin or use some heat. What shades of ignorance or stupidity—or perhaps it is simple lethargy!

Any accident victim should have the benefit of a thorough examination including adequate radiographic studies, and he should be kept under observation for twenty four to forty-eight hours. No physician, be he intern or sage, should disregard this fact nor should he minimize any complaint of the patient for fear he might be involved in a liability claim.

MEASURES USED IN TREATMENT

Many treatment measures are at our employ The following should be considered and used when indicated

1 Heat
2 Massage.
3 Injection of a local anesthetic
4 Traction
    a. Motorized intermittent traction
    b Hand controlled intermittent traction
    c. Continuous traction
5 Correction of poor posture
6 Immobilization
7 The cervical contour pillow
8 Drugs.
9 Psychotheraphy

Heat

Heat is the most frequently used treatment for the relief of pain It increases the blood supply and relieves some of the ischemia, pain and muscle spasm where applied However its prolonged use may aggravate rather than relieve the symptoms. It should be applied at the source of the irritation and is usually more efficacious when applied to the posterior area of the neck. It may be beneficial, however if applied at the site of maximum pain and tenderness.

Diathermy either microtherm or inductotherm is the type of heat which is used most universally in office practice. However hot moist packs are very gratifying to the patient. The Hydrocollator affords a convenient method for the use of hot moist packs in office and hospital practices. Many patients prefer this type of heat Between office treatments the patient should be instructed to use hot packs at home. A large bath towel placed over the neck and shoulders and hot water from a shower allowed to run on the towel for five or ten minutes will often give

relief of pain and stiffness. This is a convenient and simple method of application of moist heat which is available to most patients.

Ultrasonic heat has been effective in the treatment of painful conditions, but it should be used with great care and by one who is fully trained in its use. It can do more damage than good.

Massage

Massage following the application of heat may be beneficial Some of the very mild cases may need no other treatment Even deep pressure over a painful area may relieve *localized pain in some instances.*

The Injection of a Local Anesthetic

The most dramatic relief of pain caused by irritation of the nerve roots is obtained by the injection of a local anesthetic into the painful tender areas. This is true particularly if localized areas of pain have been present for twenty four hours or longer The local anesthetic breaks the pain reflex by paralyzing the pain receptors and conductors. It relieves muscle spasm and ischemia. Its effect may last for days, weeks or months.

The injection should be given at the site or sites of maximum deep tenderness. If the area of maximum tenderness is over the posterior articulations the injection should be given there One should be sure that the anesthetic material is placed about the posterior joints as well as in the posterior neck muscles. Frequently such an injection will relieve all the radicular pain It is not necessary nor is it possible except by the anterior route to inject the nerve roots themselves.

However if the point of maximum tenderness is in the suprascapular muscles or at the superomedial angle of the scapula the injection may be given in these areas, or in any other myalgic area The most important part of the procedure is the momentary reproduction of the radicular pain

as the needle and local anesthetic enter the painful area. If the pain is not momentarily aggravated or reproduced the injection will be of little benefit

The anesthetic should be injected in a stellate manner from the site of maximum tenderness until all pain is relieved (Figure 71) More than one injection may be necessary

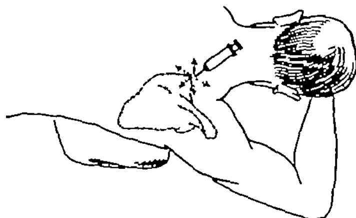


FIGURE 71 Injection of a local anesthetic in a stellate manner The patient should be in a prone position with the head resting on the hands and with a folded pillow beneath the chest

It must be remembered, as already stated, that a local anesthetic injected into areas of pain which are reflexly referred from somatic or visceral structures or pain from cord and brain lesions will not reproduce or aggravate the pain and will be of little or no value in relieving such pain.

In some instances it may be necessary or advisable to do a stellate ganglion block. Usually this procedure is not necessary unless paralysis of the sympathetic control seems essential

The choice of the type of local anesthetic to be used should be considered Procaine has been used more universally than any other local anesthetic However many patients have severe reactions following injections of this solution. During the past five years the author has used only monocaine solutions and has had no undesirable reac

tions. The so-called long lasting anesthetic agents and those with an oil base should not be used

Certain precautions should be used to prevent the possibility of an undesirable reaction The patient should be given a barbiturate fifteen or twenty minutes prior to the use of a local anesthetic A one-half per cent solution should be used rather than the usual one one and a half or two per cent solutions. Greater quantities of a one half per cent solution can be used without fear or trepidation The inadvertent injection of a one-half per cent solution into *the blood stream or the spinal canal will not be disastrous,* whereas a stronger solution might prove fatal The injection should be done with the patient lying down rather than in the upright position An injectable barbiturate should be available in the event a severe reaction does occur If however the reaction should be of the depressant type, a stimulant drug should be available If there is any history of a previous sensitivity to a local anesthetic a skin test should be made

Traction

Traction has been used in the treatment of neck injuries for many decades. It may be employed as continuous traction or as intermittent traction

Continuous traction assures a certain amount of immobilization of the cervical spine and relieves muscle spasm. If correctly applied, it straightens the cervical spine and enlarges the intervertebral foramina to relieve compressive or irritative forces upon the nerve roots. However the conventional method of application by a head halter is not well tolerated because of the discomfort to the chin and lower jaw The conventional amount of weight of five to ten pounds does nothing more than lift the weight of the head from the neck, and keep the patient still to some extent

Skull traction, by some type of tong is the most effective means of obtaining and maintaining constant traction and

any amount of weight up to forty or fifty pounds is well tolerated by the patient. However this type traction is reserved for certain fracture dislocation cases usually.

The use of mortorized intermittent traction is supplanting all other methods of traction application except of course, skeletal or skull traction. Intermittent traction relieves muscle spasm. It has a massage like effect upon the muscles and the ligamentous and capsular structures. It reduces swelling and promotes better circulation in the tissues. It prevents the formation of adhesions between the dural sleeves of the nerve roots and the adjacent capsular structures. In some instances it may free the adhesions. In some chronic cases where adhesions have been present for some time it may aggravate the symptoms of nerve root irritation because of the tug it places upon the adherent nerve roots.

Motorized Intermittent Traction

The most advantageous intermittent traction is that which can be controlled in the amount and in the duration and that which gives the maximum amount of traction with the minimum amount of discomfort to the patient's chin and jaw. This can be accomplished with the Tractolator machine which is the original intermittent traction machine designed by Griffith and perfected by Judovich and Yellin. (Other types of traction machines are now available.) Two Tractolator units (Figures 72(A)&(B)&73(A)) are available—the chair and bed units. The chair unit is recommended for office practice and the bed unit for hospital use. However the author uses both units in the office and prefers the bed unit because it allows the application of intermittent traction with the patient completely relaxed in a semi jackknife position (Figure 72(B)). Invariably the patients fall asleep during their treatments, especially if hot packs are applied to the neck during the treatment.

J. E. Miller, M.D., Chief of the Department of Radiolo-



FIGURE 72A. Motorized intermittent traction (Tractolator) (A) Chair unit.

Available through Louis Yellin, Incorporated, Philadelphia, Pennsylvania.

gy at Baylor Hospital, Mr Joseph Perrizzolo, Chief Technician and the author have done cineradiographic studies of the cervical spines of several patients during treatment with the Tractolator Ten pounds of traction as indicated on the scale of the machine, lifts the weight of the head from the neck but produces no visible distraction of the vertebrae. Twenty to twenty-five pounds of pull does produce visible distraction of the vertebrae and increases the size of the intervertebral foramina as demonstrated in the oblique position. With thirty-five pounds of pull separation is still more marked, and the normal forward curve is completely straightened (Figure 74)

Patients with post-injury and degenerative changes in the cervical spine, show little or no actual distraction of the involved vertebrae. This is due to the thickening and fibrosis of ligamentous and capsular structures (Figure 75)

Treatments should begin with fifteen to twenty pounds of traction and the pull gradually increased to thirty-five or forty pounds over a period of several treatments. Some heavy muscled patients may require as much as fifty pounds of traction

Judovich recommended injection of the anterior scalenus muscle with procaine immediately prior to the application of cervical intermittent traction.[13] The author has not followed this procedure as a routine measure It may be necessary in selected cases where there is marked spasm of the scalene muscles, or in patients whose straight lateral films show marked reversal of the normal forward curve of the cervical spine

Injection of other myalgic areas may be necessary prior to the administration of motorized intermittent traction. This should be determined by the severity and duration of the symptoms.

The author recommends daily thirty minute intermittent traction treatments for three to six days, followed by treat-

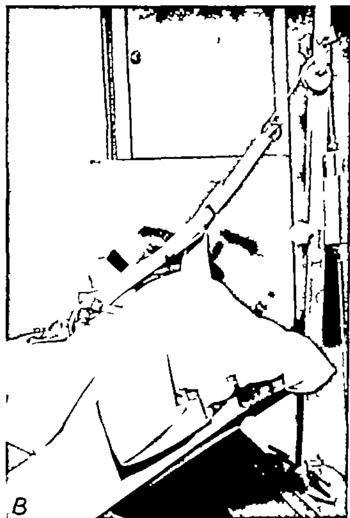


FIGURE 72B Motorized intermittent traction. (Tractolator) Bed unit set-up for office use

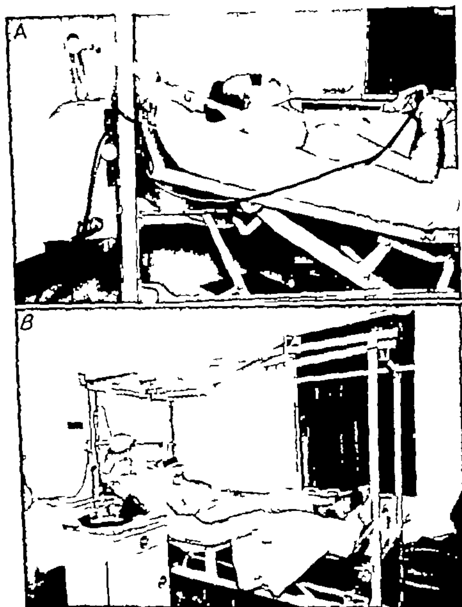


FIGURE 3(A)&(B) Bed traction. (A) Motorized intermittent traction—bed model. (B) Continuous traction



FIGURE 7 B Motorized intermittent traction. (Tractolator) Bed unit set-up for office use.

twelve to twenty-four inches away Weights may then be attached to the end of the rope for traction (Figure 76) An assistant can lift or raise the weights at desired intervals. This is a rather crude method of traction application, but it can be used if no other method is available.

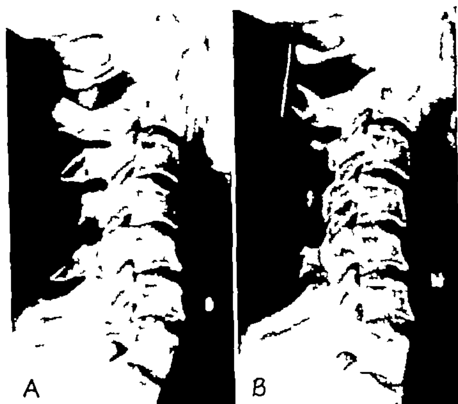


FIGURE 75 A straight lateral view of a cervical spine which had been injured ten months previously is shown in (A) Note the reversal of the forward curve. Thirty five pounds of traction produces very little distraction of the vertebrae and the reversed curve is slightly increased as shown in (B) This is due to the thickening of the ligamentous and capsular structures and to their decreased elasticity which follow sprain injuries.

A few words of caution in the use of this apparatus is indicated In as much as the amount of pull varies with the friction of the ropes on the pulleys and the position of the patient, a scale to measure the amount of pull should be placed between the patient and first pulley (Figure 76)

ment three times a week for one or two weeks Following this, one or two treatments each week may be necessary for a period of two or three weeks. However, some cases may require no more than five or six treatments Others may be kept comfortable with one treatment each week for an indefinite period of time

Hand Controlled Intermittent Traction

Another type of intermittent traction which is hand controlled has been used in office practice. The patient is placed

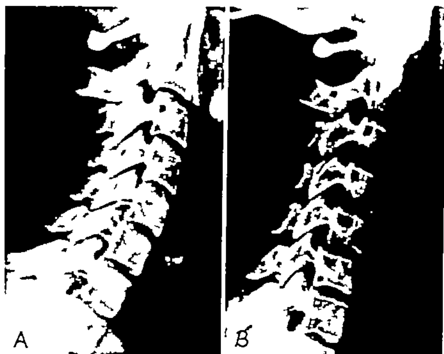


FIGURE 74 Radiographs of a cervical spine without traction is shown in (A) and with thirty five pounds of traction in (B) With thirty-five pounds of pull the cervical spine is straightened and there is visible distraction of the vertebrae The size of the intervertebral canals is definitely increased.

in a chair beneath a pulley on a hook in the ceiling A head halter is applied to the patient, a rope is attached to the spreader of the halter and placed through the pulley then through a second pulley which is placed in the ceiling

traction should be used with the weights placed in front of the patient to assure a slightly forward direction of the pull

Continuous Traction

If motorized intermittent traction is not available or if



FIGURE 77 On-the-door traction, which the patients can use at home

continuous traction is indicated the patient should be hospitalized This type traction requires constant supervision and its correct application is important The direction of the pull should be in a straight line with the neck or

The friction of the rope on the pulleys will alter the amount of actual traction so that twenty pounds of weight at the end of the rope will produce approximately fifteen pounds of traction However, if the patient slumps or slides down in the chair the actual pull may be increased to

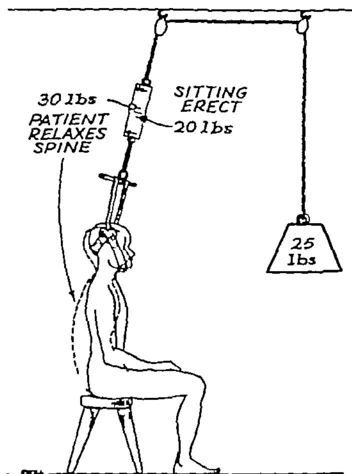


FIGURE 76 Hand controlled traction.

twenty five or thirty pounds without altering the position of the weights.

It is not advisable to use more than twenty pounds of weight with this type traction Fifty pounds of weight has caused *severe ligamentous and cord damage. It is unnecessary* and dangerous to use that amount of traction. This

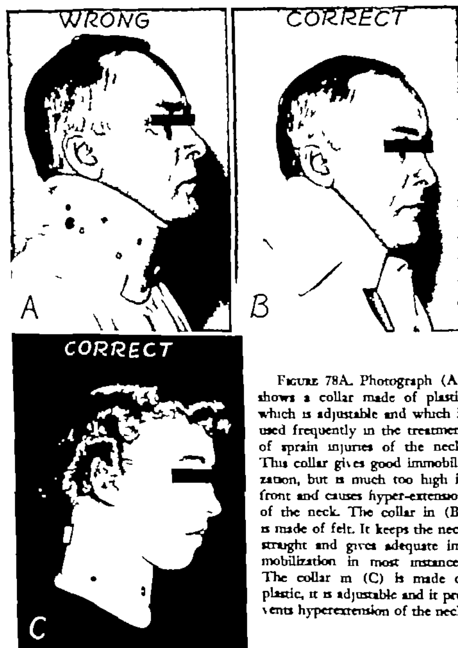


FIGURE 78A. Photograph (A) shows a collar made of plastic which is adjustable and which is used frequently in the treatment of sprain injuries of the neck. This collar gives good immobilization, but is much too high in front and causes hyper-extension of the neck. The collar in (B) is made of felt. It keeps the neck straight and gives adequate immobilization in most instances. The collar in (C) is made of plastic, it is adjustable and it prevents hyperextension of the neck.

above the neck so that the cervical spine is straightened or placed in slight flexion The patient should be in a jack knife position for complete relaxation, and a small soft roll or pillow should be placed beneath the neck (Figure 73B) A patient placed flat on a bed with traction applied to the neck suffers a great deal of abdominal distress but in the jackknife position this does not occur If the traction is applied with the neck in hyperextension the pain will usually be aggravated

The amount of weight should vary with the individual s tolerance Most patients can tolerate four to ten pounds of constant traction without too much discomfort from the head halter If halter traction causes too much discomfort it may be necessary to use head tongs for skeletal traction

It is important that the patient be sedated for twenty-four to forty-eight hours so that the maximum effects of the traction will be realized As the symptoms subside the amount of weight can be reduced and then removed for short periods. Some type of collar immobilation should be used when the patient is allowed to be ambulatory

In some instances it may be necessary to permit the patient to use traction in the home, but in no event should this be allowed without proper instruction in its correct usage (Figure 77) Woe unto the doctor who hands the patient the traction apparatus and tells him to go home and get in it for he will have an unhappy patient whose pain will not be relieved and who will look for another doctor

There are no contraindications to cervical traction if it is properly used. In rare instances it may aggravate the symptoms at first Patients who have had previous injuries to the lower back may experience pain in that area when receiving cervical traction. This is due to an adherent dura or to an adherent dural sleeve of a nerve root at that level.[14]

Correctly controlled motorized intermittent traction in the author s experience has given the best results and has greatly reduced the need for hospitalization

have healed Chronic cases may need only immobilization for short intervals.

If it is necessary to apply a collar or brace for immobilization its use should be continued until all symptoms have subsided and then it should be gradually discontinued at short intervals until the patient learns to adjust his activities to his neck or his neck to his activities.

Some of the collars used by the author are shown in Figures 78, 79 & 80 The degree of immobilization needed will determine the type of collar to be used

Posture Correction

Correction of poor posture and of poor postural habits is of utmost importantce in the treatment program, and all corrective measures should be directed toward straightening the cervical spine. Drooping of the shoulders, which causes a compensatory hyperextension of the neck, can usually be corrected by the use of some type shoulder brace (Figure 81) The brace should be worn until the patient becomes posture conscious and is able to hold the shoulders up and back without the assistance or reminder of any restrictive brace When the correct position of the shoulders is maintained the cervical spine is held in a more normal relationship and hyperextension of the neck is obliterated. This position does not obstruct the so-called cervicothoracic outlet

In some instances shoulder braces will relieve the pain associated with cervical nerve root irritation and no other treatment may be needed.

To avoid hyperextension of the neck the following in-

Immobilization

Immobilization of the cervical spine with some type of brace or collar is essential in the treatment of acute injuries. Collars or braces should be designed to hold the neck in the optimum position for healing of the sprained or injured ligamentous and capsular structures. This position must be with the neck straight and the chin "tucked in." Braces

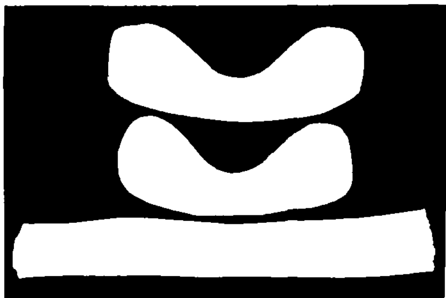


FIGURE 78B How to make a felt collar. Cut two pieces of felt as illustrated, and one piece of four inch Stockinet. Place the smaller piece on the larger piece and pull both pieces through the stockinet. The ends of the stockinet can be secured by safety pins when the collar is applied, as shown in Figure 78A(B). This collar is adequate and gives sufficient immobilization for most sprain injuries of the neck.

which hold the neck in hyperextension are completely wrong in principle and should never be used for the treatment of sprain injuries (Figure 78(A)). Immobilization in hyperextension causes further stretching of the anterior longitudinal ligament and allows the posterior ligamentous structures to heal in a shortened position.

In acute injuries immobiliation should be continued for three weeks, or until the sprained or fractured structures

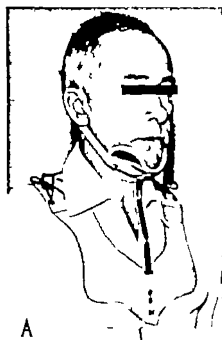


FIGURE 80A The Miller neck brace which is an excellent support when rigid immobilization is indicated

FIGURE 80B Front and side views. The Yellin neck brace. This brace is made in two pieces and is adjustable It is of minimum weight and affords adequate immobilization for treatment of cervical sprains.





FIGURE 79A Collars for immobilization of the cervical spine. The felt collar covered with stockinet is shown in (A) Collar made of sponge rubber and covered with soft white leather which is reinforced with a piece of stiff leather is shown in (B) The collar in (C) is a molded leather collar which is made in two parts, and the collar in (D) is made of celastic.


A
B
C
D

be necessary but the most essential corrective measure is the determination of the patient to help himself Braces and supports for posture improvement are only crutches They should be used intelligently and discontinued as soon as possible

The Cervical Contour Pillow

In as much as many patients complain of increased pain and discomfort at night the correction of poor sleeping posture should be considered in all instances Many people sleep on one or more pillows which causes prolonged flexion of the neck and aggravation of pain Sleeping without any pillow aggravates the symptoms. Some patients think they cannot sleep unless they are in the prone position. This keeps the neck rotated and laterally bent for long periods.

The author by a process of trial and error, developed the Cervical Contour Pillow (Figure 82) This pillow is eighteen inches long and eight inches in diameter It should be stuffed with feathers and down, or with dacron When in use it should be flattened in the center so that the neck rests on the proper amount of support for comfort. This leaves a bulge on either side which prevents too much rotation and lateral bending If the patient sleeps on his side the bulge at either end gives adequate support to assure comfort and to keep the neck straight

Lateral radiographs of the cervical spine made without any pillow under the neck with a regular pillow beneath the head and with the neck upon a Cervical Contour Pillow illustrate well the advantage of this pillow (Figure 83A, 83B & 83C)

The Cervical Contour Pillow has been one of the greatest adjuncts in the treatment of cervical nerve root irritation, and in many cases no other treatment is needed

Drugs

Drug therapy has its place, too in the treatment of these

structions are essential 1 Squat, don t stoop 2 Use a step ladder for doing work above eye level 3 Put a cushion in the car seat or raise the car seat for direct vision above the level of the steering wheel. 4 Use reading glasses rather than bifocal glasses 5 Sit straight and hold the neck straight 6 Don t prop the chin on the hands. 7 Don t slump 8 Lie down sideways and get up sideways.

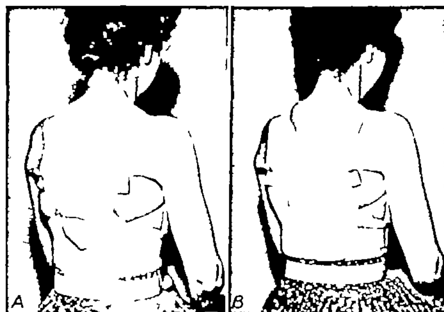


FIGURE 81 Shoulder braces to correct round shoulders and, hence, to straighten the cervical spine

To avoid prolonged flexion of the neck the following instruction should be given 1 Don t read in bed 2 Sit in straight back chairs with arm rests 3 Use a reading stand for prolonged reading 4 Lower desk chairs or raise desks. 5 Try to keep all work at or near eye level.

Many individuals sit, stand and walk as if they were falling apart, or as if they were too tired or too lazy to maintain any semblance of correct postural attitudes How ever with persistence on the part of the doctor these poor postural habits can be corrected Corrective exercises may



FIGURE 83A Photograph and radiograph of a neck with no pillow beneath it. Rotate the book ninety degrees to see the position of the cervical vertebrae

painful conditions. Any of the Mephenesin preparations, and other muscle relaxant drugs, are beneficial in many cases. Phyatromine-H, which consists of Physostigmine Salicylate and 1-Hyoscyamine Hydrobromide is of great benefit in treating those patients who have marked muscle spasm Injection of one cc may be given before the patient

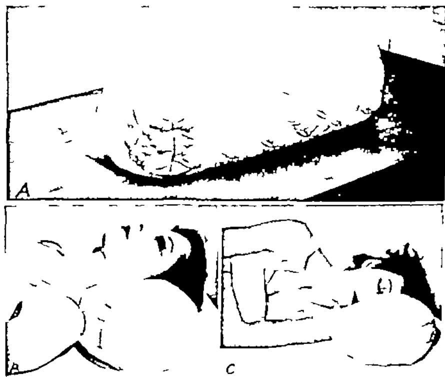


Figure 87 The Cervical Contour Pillow (Designed by the author for correct sleeping posture.)

starts his heat and intermittent traction treatment. This has eliminated the necessity for monocaine or procaine injections in many instances. A tranquilizing drug may be of value to relieve muscle spasm and tension in many cases. The usual analgesics and sedatives may be indicated in some cases for temporary relief of pain

The patient s general condition can be improved in some instances by the intelligent use of vitamins. Large doses of vitamin B_1, may be of some value in those patients who



FIGURE 83C. The same neck with a Cervical Contour Pillow beneath it. In the horizontal position the neck appears to be in hyperextension. Rotate the book ninety degrees to see that there is only a normal forward curve of the neck and no hyperextension. This is the most comfortable sleeping or supine position.



FIGURE 83B The same neck with an ordinary pillow beneath it. Rotate the book again to see the position of the vertebrae.

intermittent traction should be given daily The collar can be discontinued gradually By the end of three or four weeks no further treatment should be necessary

Patients with acute symptoms who are seen immediately after a neck-lash injury should receive daily intermittent traction treatments preceeded by some type of heat. A collar should be applied for immobilization and worn constantly for a period of two to four weeks

The patients with sub-acute and chronic symptoms may be treated with monocaine or procaine injections, depending on the severity of the symptoms, followed by daily intermittent traction treatments for one week or until all the symptoms have subsided completely Many of these cases benefit from some type of immobilization.

Patients who have severe shoulder pain with limitation of glenohumeral motion of only a few days or weeks duration should have a local anesthetic injected into the supra-scapular muscles, followed by heat and intermittent traction. Not infrequently a complete range of shoulder motion can be restored following one injection Other cases require repeated injections and supervised active exercises before motion can be restored.

The frozen shoulder may require manipulation under a general anesthetic However conservative measures should be tried first because the post manipulation convalescence requires a long period of active treatment and because dislocation of the shoulder sometimes occurs during or after manipulations If manipulation is necessary immobilization of the shoulder with the arm in ninety degrees or more of abduction should be maintained for ten days During this time the brace may be removed daily for pendulum exercises of the shoulder At the end of ten days, active exercises should be started and continued until full mobilization is restored.

If a calcium deposit is present in one of the tendons of the shoulder cuff it should be removed by aspiration under

have marked hypertrophic changes. In some instances hydrocortone or Butazolidin may be indicated If osteoporotic changes are present androgen and/or estrogen therapy may be necessary If the symptoms in women are aggravated during the premenstrual period due to hormonal imbalance, treatment should be directed toward the correction of premenstrual tension and edema.

Hydrochloric acid and calcium therapy by mouth may be necessary especially in patients past fifty years of age.

Psychotherapy

In as much as mild concussions occur with neck lash injuries some of these patients develop psychoneurotic changes. Many patients seeking relief have visited so many doctors that they have been labeled neurotics. Psychotherapy may be needed before satisfactory results are obtained

Emotional stress and strain aggravate the symptoms. In many instances a simple explanation of this fact will give the patient a better understanding of his symptoms and may help to relieve the tension associated with emotional upsets.

TREATMENT OF SPECIFIC CONDITIONS

Those patients who have severely acute symptoms with apparent locking of the facets are best treated by the injection of a local anesthetic at the site of maximum tenderness over the posterior articulation. Within a few seconds the pain will subside Gentle traction with the hands should be applied then and the head passively turned in all directions. The relief of pain and the restoration of motion are thus accomplished within a few moments Diathermy should be given for twenty or thirty minutes to permit further relaxation Some type of immobilization should then be applied and worn for at least ten to twenty days. During this interval fifteen to twenty pounds of motorized

intermittent traction should be given daily The collar can be discontinued gradually By the end of three or four weeks no further treatment should be necessary

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If a calcium deposit is present in one of the tendons of the shoulder cuff it should be removed by aspiration under

a local anesthetic and the area irrigated with saline solution until all the deposit has been removed. Then twenty five milligrams of hydrocortone acetate should be injected through the same needle This gives dramatic relief of pain and the patient usually has full painless motion within two or three days, whereas two or three weeks were required for mobilization of the shoulder prior to the use of hydrocortone Further treatment should then be directed toward the cervical spine.

Epicondylitis at the elbow associated with cervical nerve root irritation is best treated by injection of five cc of local anesthetic at the site of maximum tenderness. Through the same needle one half cc of hydrocortone acetate should then be injected. The pain will be relieved immediately following this treatment However a few hours, later the discomfort at the epicondyle may be severe for twelve to twenty four hours Usually by the second morning after the injection the patient awakens completely free of pain and with full restoration of function

Fibrotic changes in the palmar fascia, resembling Dupuytren s contractures, can be relieved, if irreversable changes have not occurred by blocking the stellate ganglion to paralyze the vasoconstrictors and improve the blood supply

Those patients who have headaches which are of cervical nerve root origin will in many instances, obtain complete relief of head pain following one or two intermittent traction treatments Others may require the injection of a local anesthetic at the level of C2 C3 and C4 or at the point of maximum tenderness over the occiput, which is the point where the main trunk of the posterior ramus of the second cervical nerve pierces the semispinalis capitis and the trapezius muscles to supply the scalp as the greater occipital nerve

In rare instances it may be necessary to resect a small

portion of this nerve to relieve persistent headaches This should be done in those very few cases which obtain relief from their headaches for only a few hours after the injection of the nerve with a local anesthetic The operation should be done under a local anesthesia to facilitate the exact localization of the nerve The patient can tell the operator the exact instant the needle pierces the nerve. The syringe should be removed from the needle then, leaving the needle in place. With another needle and syringe the surrounding tissues should be infiltrated and the incision made at the site of the previously placed needle to expose the nerve. The nerve can be resected easily after it has been freed from the accompanying occipital artery

Blurring of vision and loss of balance can be relieved with intermittent traction usually Several patients who have had uncontrolled Ménière s disease have been completely relieved by the use of intermittent traction. Some cases may require injections of a local anesthetic and immobilization of the neck before relief of symptoms is obtained.

Fractures of the odontoid process of an articular process and of the lamina should be treated by adequate immobilization until the fractures have healed Usually a brace which is adjustable for some traction effect is most comfortable. After six to eight weeks the brace may be removed for short intervals and intermittent traction started No more than ten pounds should be used during the first two or three treatments. The amount of pull can then be increased very gradually over a period of two or three weeks If at any time traction causes pain it should be reduced in amount or discontinued entirely for a few days

Overriding spinous processes which are responsible for limitation of motion pain in the neck and irritation of nerve roots in some instances may require removal for relief of symptoms O Donoghue reports good results following this procedure [22] Two of his cases are shown in

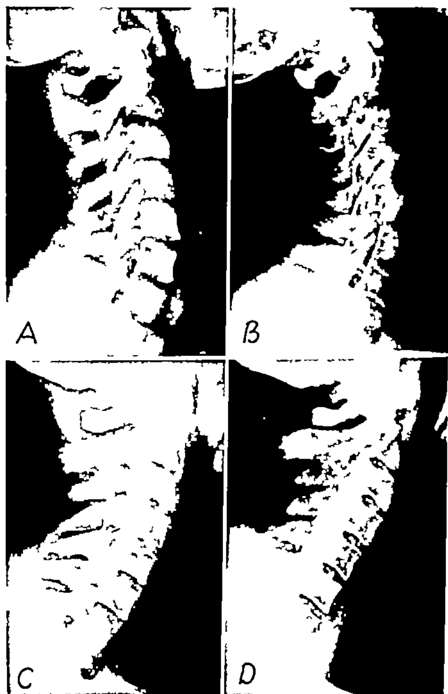


FIGURE 84 Radiographs of two cervical spines, (A) and (C) which were made with the necks in hyperextension and which show overriding of the spinous processes of the fourth, fifth and sixth vertebrae. Films (B) and (D) were made with the necks in hyperextension a few weeks following removal of the spinous processes. (O'Donoghue's cases.)

Figure 84 One of the author's cases of overriding spinous processes which was completely relieved by removal of the fifth and sixth spinous processes is shown in Figure 85 This patient had had an operation for "a ruptured disc" two years previously No "disc" was found, and the patient had continued to have the same pain in the upper rhomboid

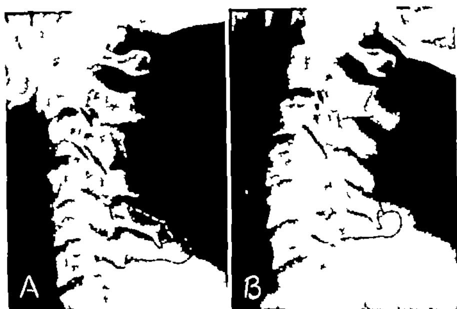


FIGURE 85 Overriding spinous processes of the fifth and sixth vertebrae. A partial facetectomy was done in 1955 to relieve nerve root compression of the sixth nerve root on the right side. The patient was not relieved of the pain in the posterior muscles of the right shoulder He was treated by the author in 1957 with motorized intermittent traction, injections of a local anesthetic and with a collar to hold his neck in a straight or slightly flexed position, with good results. However when treatment was stopped his symptoms returned Removal of the overriding spinous processes gave him complete relief

area which he had had before the disc operation The relief which he received from removal of the overriding spinous processes was most gratifying

In rare instances one may be tempted to recommend surgical explorations for some of the recalcitrant cases. It is the author's opinion that cervical laminectomies should be reserved for those cases which show positive evidence



FIGURE 86 A lateral radiograph of a patient who had an exploratory operation at the third and fourth vertebrae, in 1950 This man had had diving injuries and falls on several occasions during the previous twenty years. Prior to the surgery he had noticed some numbness of his hands which occurred while he was mowing a lawn. He had some difficulty with fine movements of his hands. Following surgery he had a very stormy convalescence for some four or five months. In 1957 he could not use his hands as well as he did prior to the operation, and at this time he has developed signs of cord compression due to the posterior subluxation of C 3 on C-4 and the inevitable increasing hypertrophic changes.

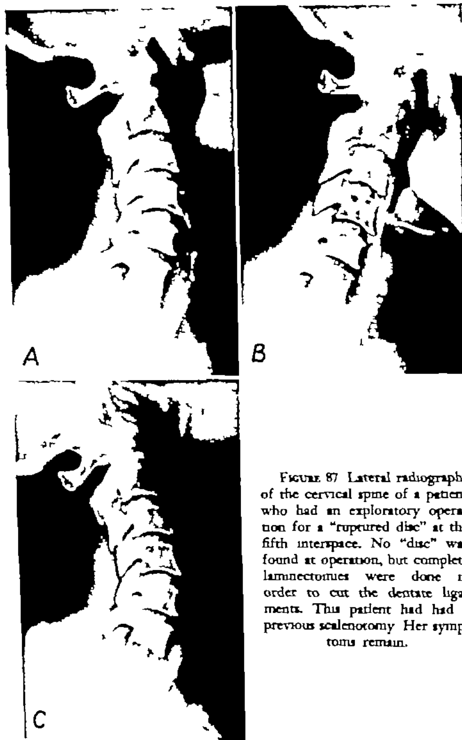


FIGURE 87 Lateral radiographs of the cervical spine of a patient who had an exploratory operation for a "ruptured disc" at the fifth interspace. No "disc" was found at operation, but complete laminectomies were done in order to cut the dentate ligaments. This patient had had a previous scalenotomy Her symptoms remain.



FIGURE 88. Radiographs of the cervical spine of a patient who first had symptoms of cervical nerve root irritation in 1950. After a short six days of traction failed to relieve the pain in her right shoulder and arm, the fifth, sixth and seventh vertebrae were fused. Several months later following myelographic studies, a "ruptured disc" was removed between the sixth and seventh vertebrae on the right side. Several months later the upper portion of the cervical spine was explored and screws were used across the joints for fixation. Eight months later the screws were removed and a cordotomy was done. In 1957 the patient still had irritation of the cervical nerve roots, plus a stiff neck and complete loss of sensation on the right side[1]

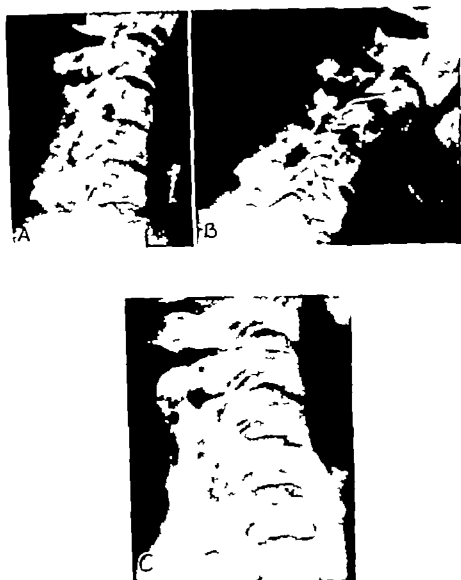


FIGURE 89 Lateral radiographs of a patient who had an exploratory operation of the fourth left nerve root and a spinal fusion of the third, fourth, fifth and sixth vertebrae, three years previously. She had been in an automobile accident seven years prior to surgery and had had symptoms of nerve root irritation for six months. In 1957 her symptoms of nerve root irritation are still present and she has the added burden of a stiff neck.

of cord compression from subarachnoid space occupying lesions

Surgical procedures on the cervical spine are not too difficult, but the aftermath may be devastating to the patient. Figures 86, 87, 88 and 89 are interesting examples to contemplate. Conservative treatment may be discouraging in some cases, and it is time consuming in many cases. However, if one can learn the art of conservatism, the results will be gratifying.

If one must operate on a patient for persistent and resistant nerve root irritation, a simple facetotomy is the procedure of choice (Figure 90). It is in the intervertebral canals that irritation of the cervical nerve roots occurs. Removal of the posterior wall of the canal will enable exploration of the nerve root and will relieve the compressive forces upon the nerve root by elimination of the posterior confining wall. Adhesions about the nerve root can be freed, and even the spur formation at the margins of the lateral interbody joint can be removed if necessary.

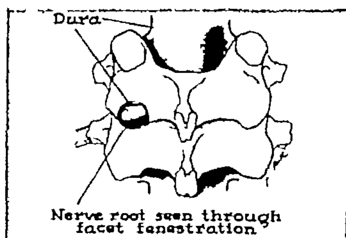


FIGURE 90. Facet fenestration to relieve nerve root compression. This is the simplest operation for decompression of a cervical nerve root. A laminectomy is not necessary unless there are indications of cord compression.

CONCLUSIONS

In conclusion it must be stressed again that treatment should be definitive and individualized Good results can be obtained by conservative measures but the problem of permanent damage to the ligamentous and capsular structures of the joints, as well as to the intervertebral discs, remains.

It is impossible to estimate the exact amount of residual disability but it can be stated with certainty that these joints will be intolerant of unusual stress or strain They will be subject to further damage on even slight provocation. Patients should be taught the importance of proper usage and protection of their necks to prevent recurrent attacks of pain and disability The resulting disability will be dependent upon the functional demands made upon the cervical spine and upon the ability of the patient to adjust to and to tolerate the limitations imposed upon his activities. Even with guarded usage degenerative changes are inevitable However, early recognition and treatment of sprain injuries of the neck may minimize or delay the late degenerative changes.

Surgery should be avoided unless there are absolute and definite indications for it otherwise the results from operative procedures will be disappointing and the symptoms may be worse than they were before surgery was done. These cases are treatment cases which require time, patience and understanding but the results will be gratifying

The surgeon who believes that his scalpel can cure the ills of the cervical spine should take time to live with his patients before and after surgery If he does this, he would be more cautious in the selection of patients for cervical spine surgery The most beautiful surgical technique may fail if there is not the proper indications for its execution. The patient's future must be of prime concern.

The importance of cervical investigation in any patient with head neck, chest, shoulder and arm pain cannot be

over-emphasized The usual diagnosis of arthritis, bursitis, neuritis, muscular rheumatism, fibrositis, fasciitis, tendinitis, pseudo-angina, migraine, etc. should not be made until cervical nerve root irritation has been ruled out entirely, if that is possible

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